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ABSTRACT

Presented is a non-technical account of the geological appearance and history of the state of Iowa. Included are Iowa's landscape features, geologic events, and processes that shaped the landscape. Maps and numerous illustrations picture the events and landforms described. Each of the state's seven principal landform regions is discussed in detail. (SL)

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A REGIONAL GUIDE TO

IOWA LANDFORMS

U.S. DEPARTMENT OF HEALTH,
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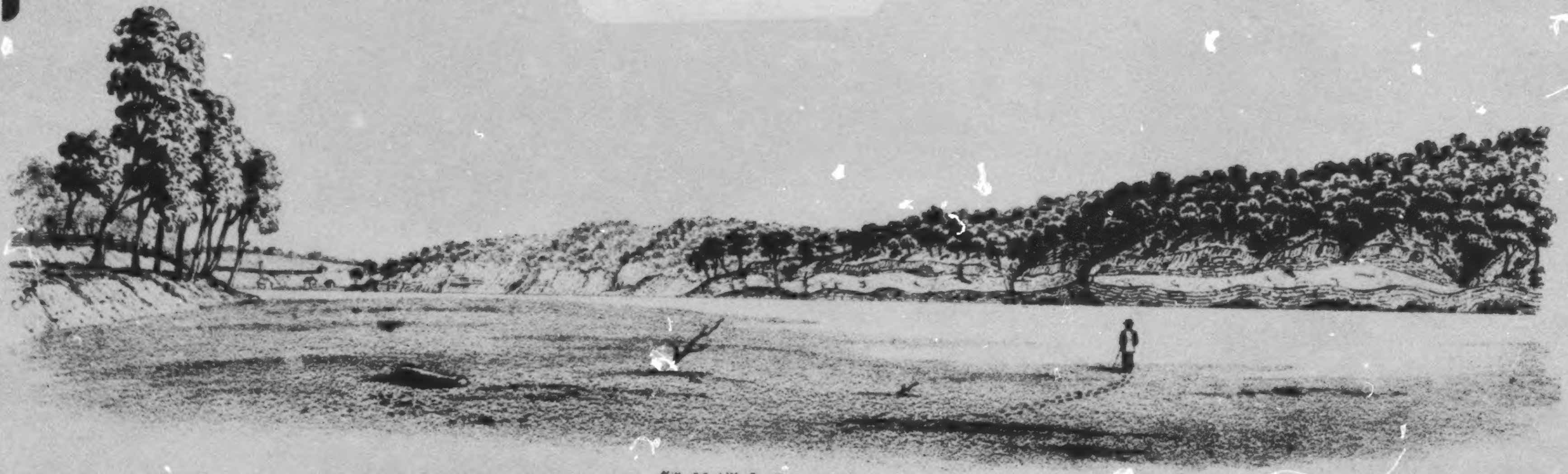
by
Jean Cutler Prior

Iowa Geological Survey
Educational Series 3



Mills & Co. Lith Des Moines, Iowa.

VIEW ON THE DES MOINES, ONE MILE ABOVE KEOSAUQUA, VAN BUREN CO, LOOKING EASTWARD. EXPOSURE OF ST LOUIS LIMESTONE WITH INTERLOCATED SANDSTONE BED.
1868

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ABOUT THE COVER

On October 29, 1868, Orestes H. St. John, then Assistant State Geologist of the Iowa Geological Survey, sketched this view along the banks of the Des Moines River. This lithograph, prepared from his sketch, appears in the *Report on the Geological Survey of the State of Iowa,* Volume I, 1870, by Charles A. White. The original field sketch, plus four others done by St. John, recently were acquired by the Iowa Geological Survey and appear in figures 1-5. St. John's hand-written note on the original reads: "View on the Des Moines one mile above Keosauqua, Van Buren Co., Iowa—In bluffs on right side of river Saint Louis limestone exposures with intercalated layer of sandstone "a"—(29th October 1868), (Looking eastward, from north or left bank of the river.)" The superimposed letters "S" and "J" appear along the lower left-hand margin, a characteristic signature on all of St. John's illustrations.

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by

Jean Cutler Prior
Research Geologist
Iowa Geological Survey

Iowa Geological Survey
Educational Series 3

Published by
The State of Iowa
1976

Stanley C. Grant
State Geologist

PREFACE

It is the spring of the year, a good season to bring forth a document which has been wintering, half-written in my mind for some time. Not that the wait has been without benefit, for it has taken me to many parts of Iowa on projects that helped me to become more familiar with the land. Also, I have been assured in countless classrooms and on field trips that a guide to the landforms of Iowa is needed and would be a useful and interesting publication. If a more authoritative voice needs to be added, a letter found in our Survey files, written in 1897 to then State Geologist Samuel Calvin, closes (following comments on some technical reports): "I wish, however, that your survey might introduce some essays more directly suited to your public school teachers. I think they are a much neglected class, in the way of state publications. Very truly yours, William Morris Davis."

So this publication is written for the teacher and the student. It is also for those who want a basic but non-technical understanding of Iowa's terrain as they apply their professions to the state's natural resources and to environmental protection. True, geology is a realm of exquisite mineral crystals and fossils of ancient life-forms, but it also has relevance to a modern world that sees man increasingly in conflict with the natural environment he inhabits. Consideration of the landscape and the characteristics of earth materials found beneath the land surface is essential in any decision-making process regarding man's use of the land.

Finally, learning more about the landscape is important to us for other, less clearly defined reasons. We know only that the land draws our attention and interest, that we enjoy and need open space, if not perpetually, at least periodically. It is important for us to feel close to the land, to realize what has gone on before, to sense something of our past heritage and that of the earth, to know of the antiquity of the land's existence and feel the "moment" of our own existence with respect to the enormity of time. It is for all these reasons that this publication on Iowa landforms is written.

My introductory comments would not be complete without an expression of thanks to those fellow workers and friends who contributed their talents and support, particularly Samuel J. Tuthill, former State Geologist, for his encouragement of the project, Donald L. Koch for his editorial guidance, Stanley C. Grant, Bernard E. Hoyer, Raymond R. Anderson and M. Patrick McAdams for their assistance with the aerial photography, James C. Case for processing and printing photographs, John L. Knecht for drafting the illustrations, and Wilma V. Gould for her secretarial skills. Photographs are by the author or the Survey's Remote Sensing Laboratory team unless otherwise indicated.

Dedicated to
my parents
Thomas and Martha Cutler

Jean C. Prior
Iowa City, Iowa
June, 1976

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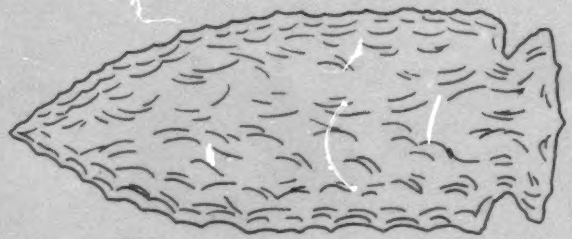
INTRODUCTION

> *"Then as to scenery (giving my own thought and feeling), while I know the standard claim is that Yosemite, Niagara Falls, and the upper Yellowstone and the like, afford the greatest natural shows, I am not sure but the Prairies and Plains, while less stunning at first sight, last longer, fill the aesthetic sense fuller, precede all the rest, and make North America's characteristic landscape."*
>
> —Walt Whitman
> *Specimen Days*
> 1879

Landmark—the very word echoes a fundamental relationship between man and the land—the recognition by man of distinctive features of the terrain. Man has looked to these distinctive landscape features to guide his travels, inspire his songs, provide his living, diversify his recreation and define his "home." Iowa's land and its layered geologic foundation lying unseen beneath have touched the lives of travelers and residents, past and present.

Mound-building tribes who once lived on this land formed tools out of flint nodules taken from limestone bluffs, and buried their dead on the high grounds which overlook major river valleys. Great river trails were blazed along the bordering valleys of the Mississippi and the Missouri during the expeditions of Marquette and Joliet, and Lewis and Clark. Into the territory bounded by these rivers moved Iowa's first white settlers, no doubt viewing the rolling prairies with some relief and a new sense of freedom after the long journey through the confining forests of Pennsylvania, Ohio and Indiana. The open land was the goal they sought. Even so, travel was slow, and by our standards difficult, as these travelers continuously were confronted with the hazards of marshlands, hillslopes, stream valleys and rock-strewn fields. However, the very slowness provided opportunities to recognize the details and differences of the landscape around them. The prominent ridge on the horizon, the place where major rivers joined, the position of a large boulder, or the coloration of surrounding rocks and soil—these became landmarks which guided the settlement of this state. Those who stayed found fertile soils beneath the tall-grass prairie cover. Each growing season since then, generations of Iowa farmers have retraced the familiar contours of their land with plows and planters.

Men who came to this state recorded through their talents their feelings for the land they saw about them. The words of Walt Whitman quoted above and the brush strokes of artist Grant Wood convey to others something of the mood of Iowa's land. Early geologists such as Samuel Calvin and Charles R. Keyes left county-by-county accounts of the geologic history which they interpreted from the clays, boulders, fossils and rocks of Iowa's land. Currently, the attention of Iowans is focused again on the land, recognizing in this time of urban growth, industrial expansion, energy shortages and environmental



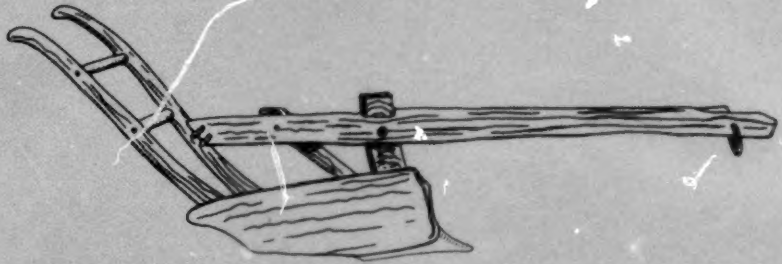
PERE MARQUETTE - SIEUR LOUIS JOLLIET - 1973 -
EXPLORERS
FOX-WISCONSIN WATERWAY MAY-JUNE

awareness that Iowa's land supports a unique agricultural heritage and is endowed with abundant surface- and ground-water resources as well as important mineral resources. To protect and properly manage these natural assets, to plan and guide future growth within the limitations imposed by geologic history are goals of pending landuse legislation.

Thus, Indians and artists, farmers and scientists all had a special relationship with Iowa's land, a special way in which their lives were influenced by the land, a special viewpoint from which they regarded their surroundings. The purpose of this publication is to describe the land they saw and the land you see and live with in different areas of the state. What are Iowa's landforms and what do they look like? What landform features characterize an individual region, and distinguish it from other regions? What are the landforms made of and how were they formed? These questions arise naturally in the minds of many Iowans and visitors to our state. As the face of a man reflects something of the tranquility and turmoil of past years and events in his life, so the lined and wrinkled terrain of the Iowa landscape reflects a fascinating accumulation of past events.

There are seven fundamentally different topographic regions in the state: the Paleozoic Plateau, the Western Loess Hills, the Alluvial Plains, the Des Moines Lobe, the Southern Iowa Drift Plain, the Iowan Surface and the Northwest Iowa Plains. Each region is discussed in regard to the shape of the land surface, the materials which underlie the surface, and the geologic history that explains the present appearance of the landscape.

Before examining these distinctive regions, it is useful and interesting to look at the subject matter, Iowa landforms, as looked at by previous observers and from different perspectives. We will see how Iowa's landforms are studied and what methods are available to assist in examining them. In addition, we will review the geologic events and processes that shaped the state's land surface.



PERSPECTIVES ON IOWA LANDFORMS

> ***"It requires but a little careful attention to discover that even the surface of the country varies from township to township if not from section to section and a wider and larger survey may even reduce such variation to order and raise the suspicion, at least, that the diversity discovered is after all intelligible, proceeds in order, and follows as effect to some widely efficient cause. In this way the apparent simplicity of the prairie takes on a more than passing interest and becomes, county after county, as studied, so many pages in a volume which is at length to delight us as it makes clear to all men, at once the history of the past and the meaning of the present."***
>
> —Thomas H. Macbride
> ***Geology of Hamilton and Wright Counties***
> (Iowa) 1910

The study of landforms is known as *geomorphology* or *physiography*, an area of specialization that is offered as part of college curricula in the fields of geology and physical geography. Today's geomorphologists receive specialized training, utilizing space-age technology and sophisticated computer applications to observe and analyze the terrain. In contrast, early students of landscape morphology were naturalists in the classical sense of the word. Their descriptions of the landscape and theories on its evolution were but part of a broad range of interests in natural features of the earth's surface. Their days in the field on foot and horseback resulted in significant observations on plants, animals, and prehistoric culture as well as physiography and geology.

Reports on the geology of individual Iowa counties, published during the late 1800's and early 1900's in the Iowa Geological Survey *Annual Report* series reflect this naturalist's point of view. These reports were authored by such men as Samuel Calvin, Thomas Macbride and Bohumil Shimek—men equally at home in several fields of natural history now regarded as separate scientific disciplines—geology, botany and zoology. It is not unusual to see these county geological reports supplemented with extensive botanical reports on prairie and forest flora, as well as meteorological records or information on archaeological remains.

In fact, the Iowa Geological Survey *Bulletin* series published between 1900 and 1930 devotes whole volumes to such topics as grasses, weed flora, rodents, raptorial birds and honey plants of Iowa. Louis H. Pammel, Ada Hayden and Charlotte M. King were recognized botanists who served as special assistants on the Geological Survey staff to help fulfill the Survey's 1892 legislative mandate to (in addition to classical geological pursuits): "investigate the characters of the various soils and their capacities for agricultural purposes; the growth of timber, the animal and plant life of the state, the streams and water power, and other scientific and natural history matters that may be of practical importance and interest."[1] Thus, this broad approach to natural science characterized the role of geological institutions as well as individual geologists.

Not only did many of the early observers of Iowa's terrain look at the landscape from the encompassing viewpoint of the natural historian, but their written and illustrated accounts show them to be gifted writers and artists as well. There is much insight to be gained about one's surroundings, by the layman as well as the geologist, from the highly readable county geological reports described above. Calvin, Macbride and Shimek, in addition to other early Iowa geologists such as Charles R. Keyes, William H. Norton and H. Foster Bain, wrote in a personal, almost poetic style seldom used in today's technical literature. For example, Shimek in describing the bluffs and ridges bordering the Missouri River valley wrote:

[1] Code of Iowa, Geological Survey, Chapter 305.4, p. 1357, 1975.

> *"During the day these bluffs may burn in the heat of the midday sun, they may be swept by the hot blasts of summer winds, or hidden in the whirling clouds of yellow dust which are carried up from the bars of the great river; but in the stillness of early morning, and again when the peace and quiet which portend the close of day have settled upon them, they are both restful and inspiring when looked upon from the valley; and there is no grander view in the great Mississippi-Missouri valley than that which is presented under such circumstances from their summits,—on the one hand over the broad valley and on the other across the billowy expanse of the inland loess ridges which appear like the giant swell of a stormy sea which has been suddenly fixed."*
>
> —Bohumil Shimek
> *Geology of Harrison*
> *and Monona Counties*
> (Iowa) 1910

Prior to the widespread availability of photographic techniques, some of these early geologists developed great skill in illustrating their publications with black and white line drawings, pencil-sketched in the field. These sketches and drawings are truly works of art, accurately proportioned with meticulous attention to detail. Some of these first views of Iowa's terrain were drawn by United States geologist David Dale Owen and published in his 1852, 638-page volume titled *Report of a Geological Survey of Wisconsin, Iowa and Minnesota.*

Orestes H. St. John was another of these talented geologists. In 1870, the Iowa Geological Survey under the direction of Charles A. White published the *Report of the Geological Survey of the State of Iowa, Volumes I and II.* Orestes St. John was Assistant State Geologist during this period and these volumes are beautifully illustrated with his field sketches. In April of 1975, the Survey was privileged to receive from Dr. Ian Campbell, former State Geologist of California, pencil sketches drawn by St. John that somehow had found their way into the files of the California Division of Mines and Geology. These sketches are originals of the sketches printed in the 1870 volumes, and they are shown here (figs. 1-5) for their historical interest, their artistic excellence, and their scientific value as illustrations of Iowa landforms.

1
2
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11
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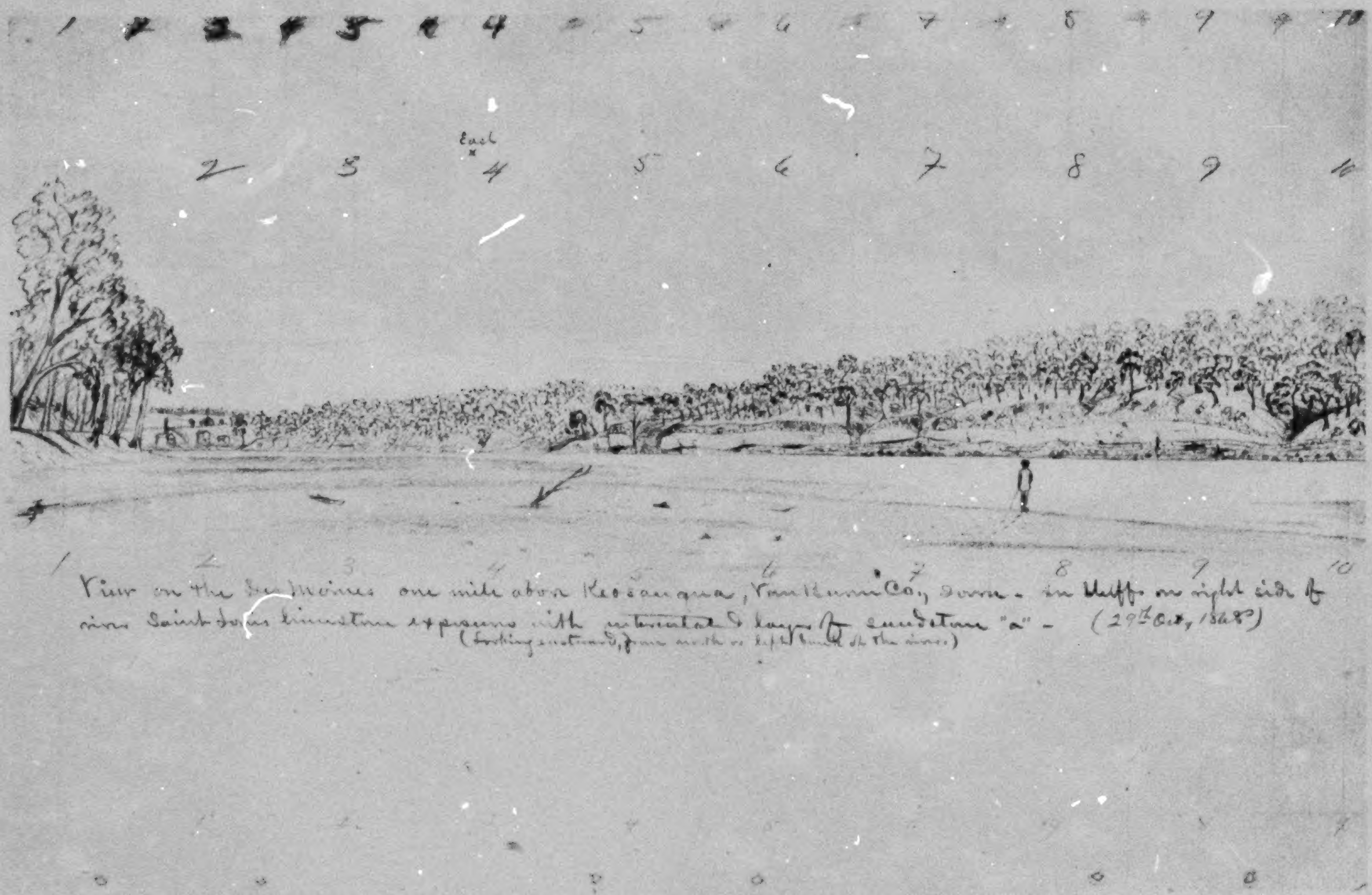
25 Sept., 1868.
Lake Minne-tonka (West Okoboji) from upland ridge 45 feet above lake at southern extremity of the lake – looking Northward.

Figure 1. "Lake Minne-tonka (West Okoboji) from upland ridge 45 feet above lake at southern extremity of the lake—looking Northward. 25th Sept., 1868." Original field sketch by Orestes St. John.



View on the Des Moines one mile above Keosauqua, Van Buren Co., Iowa. — In bluffs on right side of river Saint Louis limestone exposures with intercalated layer of sandstone "a" — (29th Oct., 1868)
(looking eastward, from north or left bank of the river)

Figure 2. "View on the Des Moines one mile above Keosauqua, Van Buren Co., Iowa. In bluffs on right side of river Saint Louis limestone exposures with intercalated layer of sandstone "a"—29th Oct., 1868 (Looking eastward, from north or left bank of the river.)" Original field sketch by Orestes St. John.

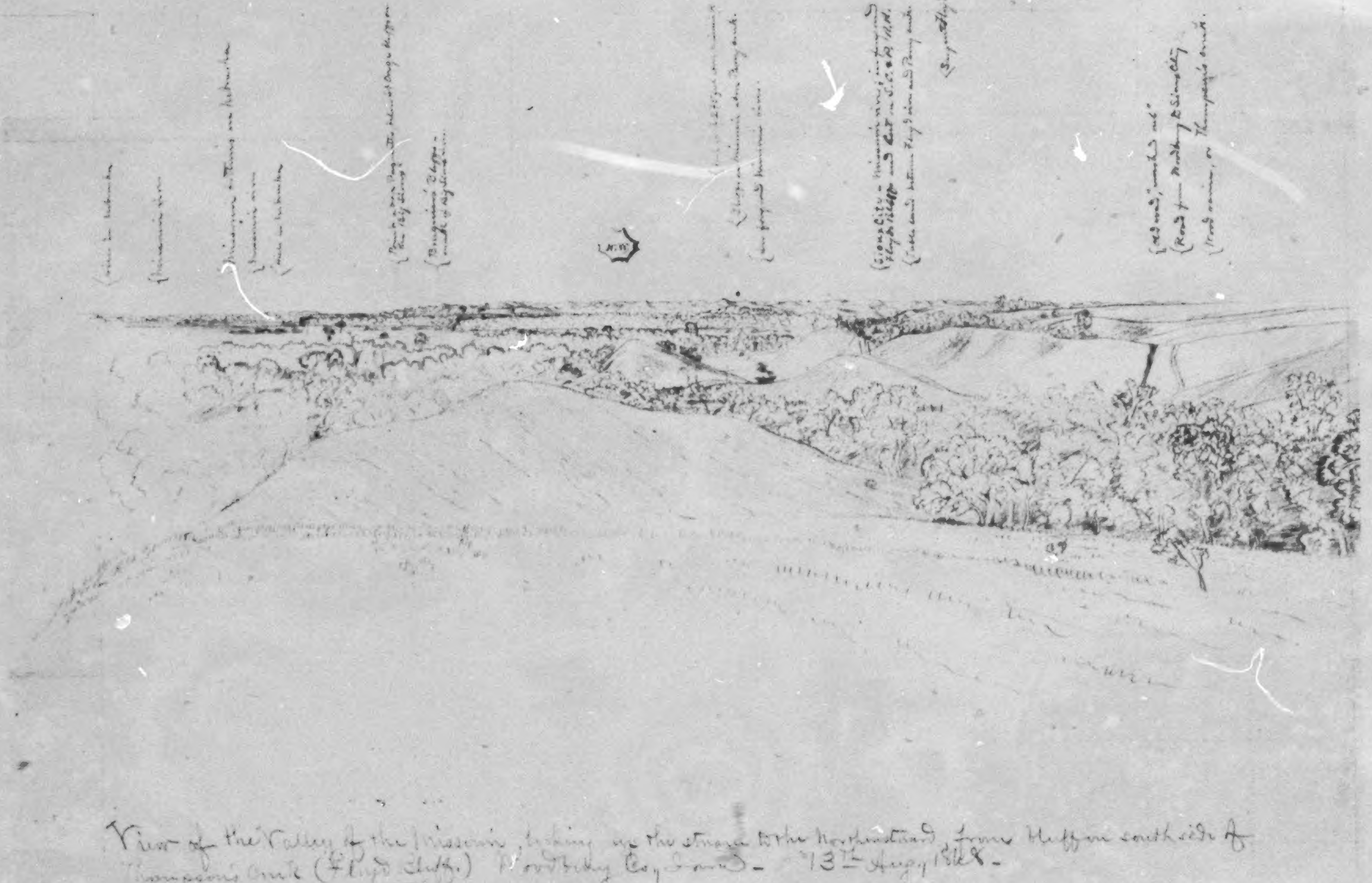
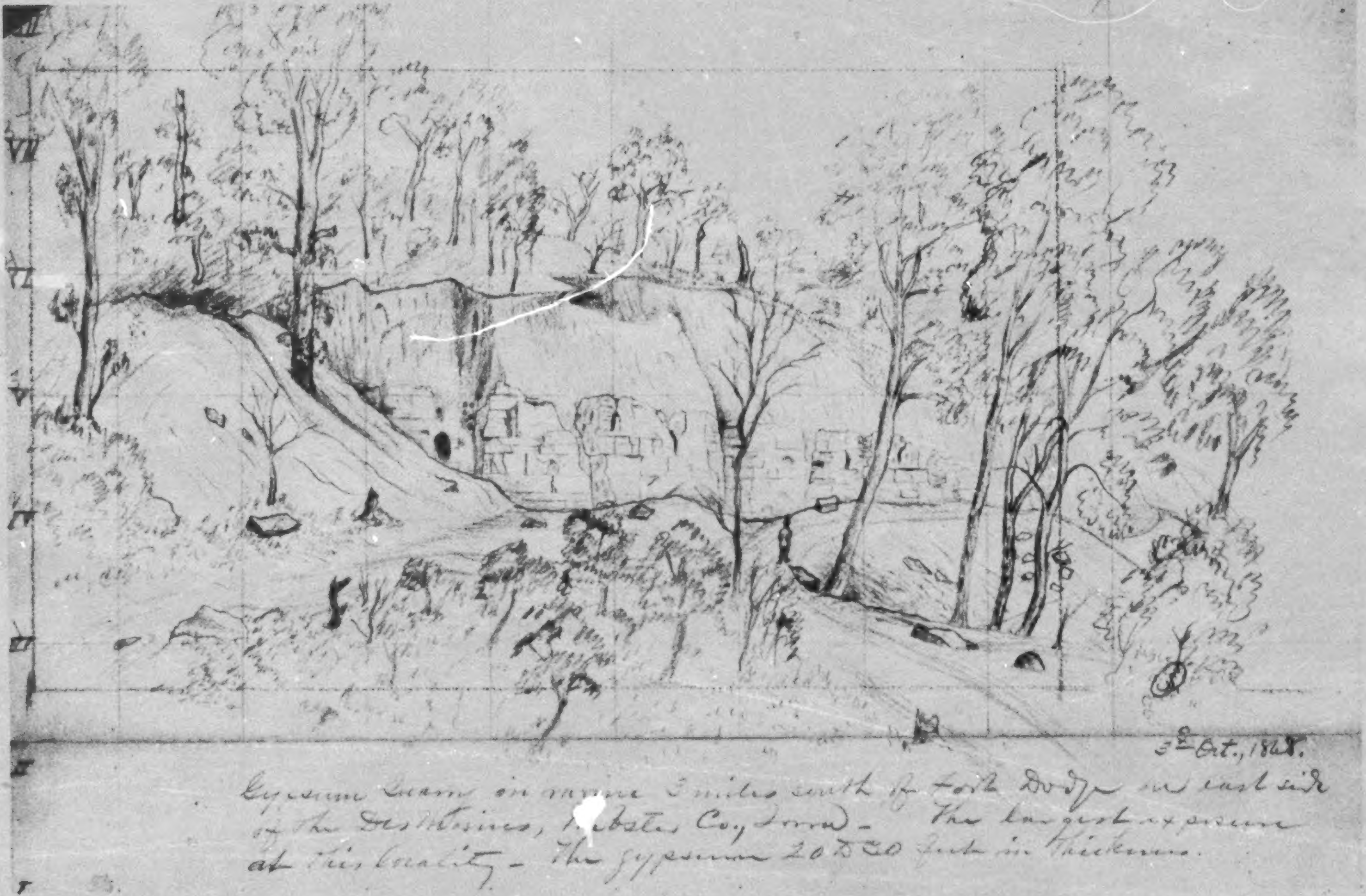

View of the Valley of the Missouri, looking up the stream to the Northwestward, from bluff on south side of Thompson's Creek (Floyd Bluff) Woodbury Co, Iowa - 13th Aug, 1868 -

Figure 3. "View of the Valley of the Missouri, looking up the stream to the Northwestward, from bluff on south side of Thompson's Creek (Floyd Bluff) Woodbury Co., Iowa—13th Aug., 1868." Original field sketch by Orestes St. John.



3rd Oct., 1868.

Gypsum Quarry in ravine 3 miles south of Fort Dodge on east side of the Des Moines, Webster Co, Iowa – The largest exposure at this locality – The gypsum 20 to 30 feet in thickness.

Figure 4. "Gypsum Quarry in ravine 3 miles south of Fort Dodge on east side of the Des Moines, Webster Co., Iowa—The largest exposure at this locality—The gypsum 20 to 30 feet in thickness. 3rd Oct., 1868." Original field sketch by Orestes St. John.

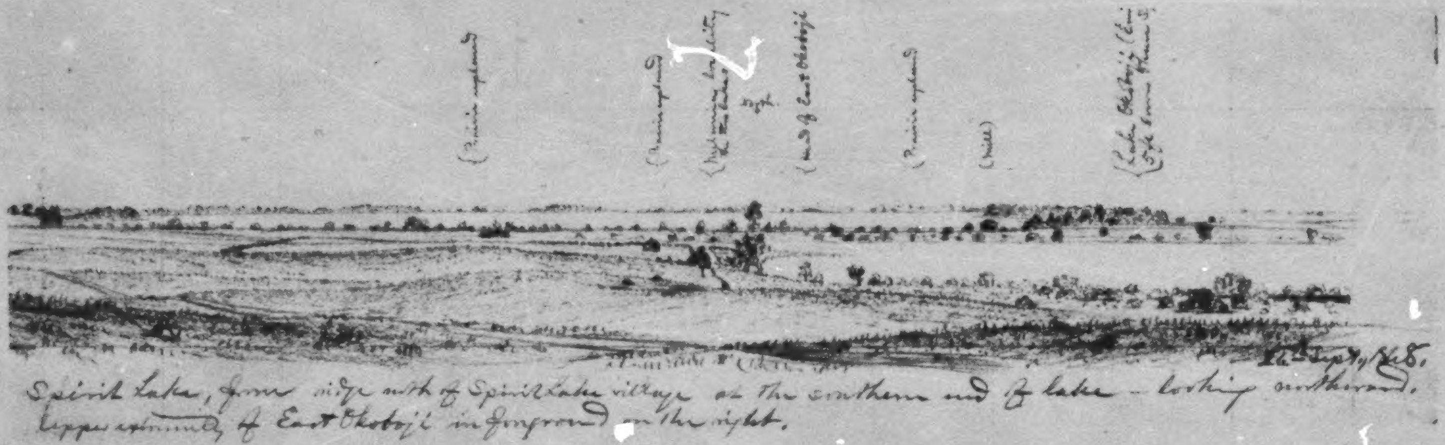

Prairie upland
(Hill)
(end of East Okoboji
26th Sept. 1868.
Spirit Lake, from ridge north of Spirit Lake village at the southern end of lake – looking northward.
Upper extremity of East Okoboji in foreground on the right.

Figure 5. "Spirit Lake, from ridge north of Spirit Lake village at the southern end of lake—looking northward. Upper extremity of East Okoboji in foreground on the right. 26th Sept., 1868." Original field sketch by Orestes St. John.

Following the era of the geologist-naturalist, the study of landforms became a more specialized field of study within the professions of geology and geography. Topographic maps and aerial photography replaced line drawings as important techniques in the illustration and study of Iowa's surface terrain.

Topographic maps display the configuration and elevation of the land surface through the use of contour lines. These lines connect points of equal elevation of the land surface above sea level, and their arrangement and spacing on the map delineate the three-dimensional land surface (fig. 6). A person familiar with the basic principles of reading a topographic map can easily visualize the *relief*, or inequalities of the land surface, and the shapes of its individual landforms—river floodplains, valley sideslopes, hills, and upland surfaces and divides.

Topographic mapping of Iowa began in the 1880's, and until 1950 only limited areas of the state were covered on maps of various scales. Then in 1950 the U.S. Geological Survey, in cooperation with the Iowa Geological Survey, began a concentrated mapping program to provide complete topographic coverage of Iowa at the 1:24,000 scale, the popular 7½′ quadrangle. As of June 1976, coverage of the state at this scale is about 60% complete. A series of 18 sheets at a 1:250,000 (2°) scale also is available and does provide a complete, though less detailed look at the state. Topographic maps for the state of Iowa, at these scales and others, may be purchased from the Iowa Geological Survey. An *Index to Topographic Mapping in Iowa,* showing the areas of the state completed thus far, is available on request from the Survey.

Topographic maps also permit detailed measurements of landform dimensions; that is, they provide a means to quantify geomorphology. This use of geometry offers another perspective from which to examine landforms, and in Iowa, the technique is applied in particular to analysis of drainage basins. For example, land slope, density of streams in a given area, the *order* of branching tributaries and lengths of streams all receive attention when techniques of *morphometric analysis,* or measurement of landforms, are applied to a drainage basin.

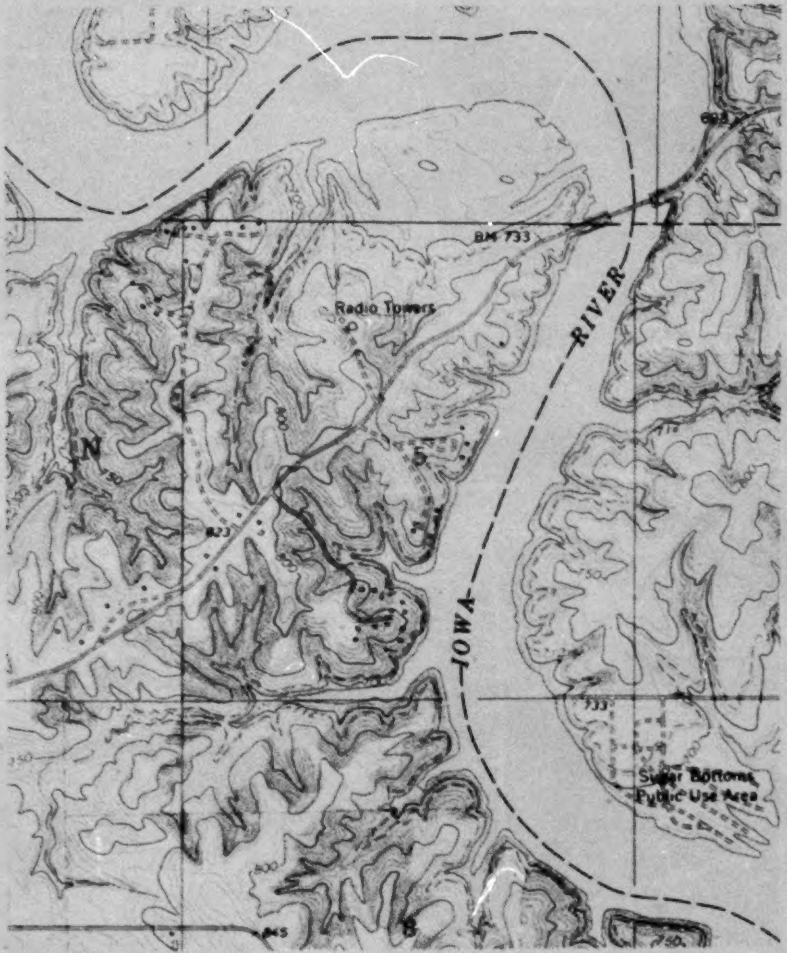


Figure 6. Portion of Ely, Iowa, 7½′ topographic quadrangle. The arrangement and spacing of the contour lines (brown) represent the shape and relief of the land surface. This area along the Iowa River-Coralville Reservoir north of Iowa City, shows County Hwy. F28 from North Liberty to Mehaffey Bridge and Stainbrook Geological Preserve. Scale is 1:24,000 or 1 inch = nearly .4 mile. Compare with figure 7.

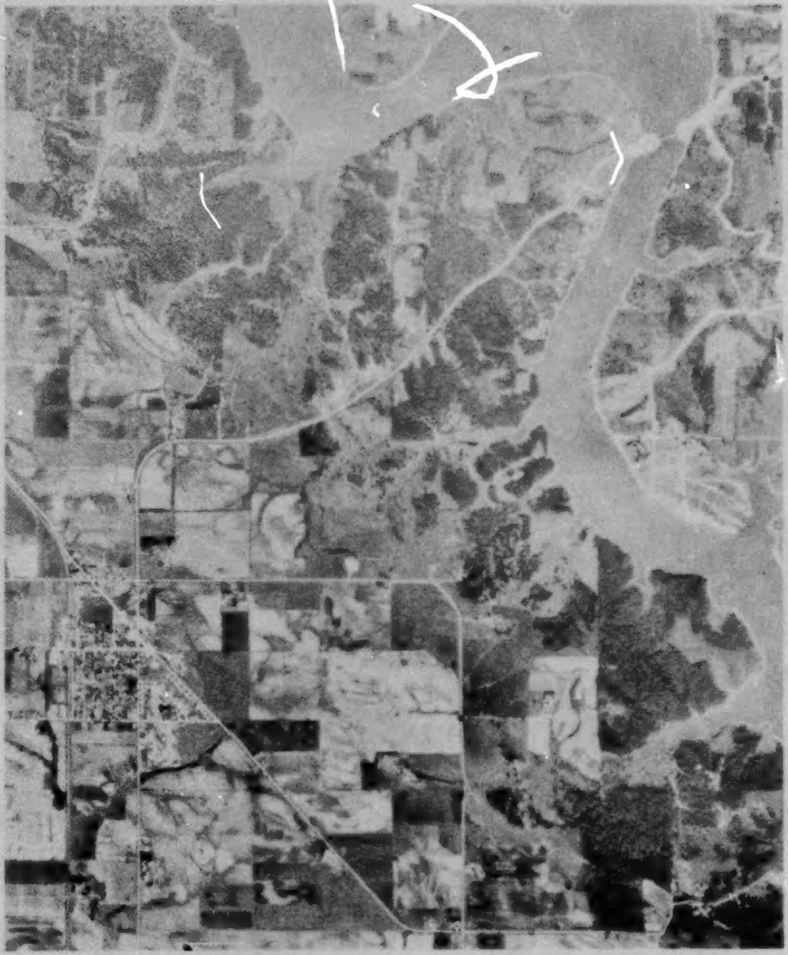


Figure 7. Portion of U.S.D.A Soil Conservation Service black and white aerial photograph. Note the differences in terrain and landuse between North Liberty and Mehaffey Bridge. Scale is 1:38,000 or 1 inch = over .6 mile. Compare with topographic map at left. Note differences in area covered at different scales.

In contrast to the graphic representation of the land's surface on topographic maps, aerial photographs are film records of actual views of the terrain. Sun angle, shadows, soil moisture, vegetation and land use are features of air photos that can be used to advantage to examine landforms and their evolutionary history (fig. 7).

The most common aerial imagery available for Iowa is standard black-and-white panchromatic. Many people are familiar with the 9 x 9 inch black-and-white prints acquired periodically by the U.S. Agricultural Stabilization and Conservation Service (ASCS), and the USDA Soil Conservation Service (SCS). Because agricultural and crop information is the primary reason for this photography, these photos generally are obtained in late spring or summer. In addition, limited amounts of color, black-and-white *infrared* and color-infrared imagery have been obtained by various state and federal agencies. *A Guide to Aerial Imagery of Iowa* was prepared by the Iowa Geological Survey Remote Sensing Laboratory in 1974 and is available as Public Information Circular No. 8. Available imagery of Iowa from all sources is indexed in this publication.

Methods of looking at Iowa landforms have progressed through history from artists to astronauts. The United States space program is realizing many practical benefits as cameras in space are focused on Planet Earth. Images from orbiting satellite platforms and manned spacecraft are not far removed in concept from aerial photography, but this step into space provides repetitive views of larger areas of the earth's surface. We can view the Iowa landscape from a time and distance perspective never seen before, and through the "eyes" of different camera-film combinations. At these distances, regional terrain features and patterns stand out, enhanced by regional drainage networks, and often accentuated by a partial cover of snow. This examination of the earth's surface from a distance, using camera and film systems sensitive to various wavelength ranges (bands) of the electromagnetic spectrum, is termed *remote sensing*. This important new technique is being used not only by those studying the shapes and patterns of the earth's terrain, but by those interested in mineral resources, water quality, forestry, wildlife management, and urban and transportation planning, to name a few.

Space-age views of Iowa have been received from two programs thus far, ERTS (now LANDSAT) and SKYLAB. Two Earth Resources Technology Satellites, ERTS-1 and 2, were launched in 1972 and 1974 respectively, to examine the earth's natural resources. Cloud cover permitting, composite views of Iowa are obtained every nine days, as the satellites complete their staggered orbiting schedules 575 miles (925 km) above the earth's surface (fig. 8). SKYLAB is a 270-mile high (434 km) orbital workshop and was manned by three different

Figure 8. Computer-enhanced, color-infrared LANDSAT I image of central Iowa. This May, 1975 satellite view of central Iowa from 575 miles above the land surface shows the city of Des Moines just left of center, and Red Rock and Rathbun Reservoirs to the southeast. The boundary between the Des Moines Lobe and the Southern Iowa Drift Plain is seen clearly; note the contrast in landuse between the plowed fields of the Des Moines Lobe, and the vegetative cover (red) of permanent pasture and forest in southern Iowa. Also note drainage patterns and the grid of section-line roads.

05-17-75 5028-16070 JPL/IGS
Billingsley/Lucas/Taranik

astronaut crews during 1973-1974. Many of their experiments dealt with the collection of earth-resources data. Again, the *Guide to Aerial Imagery of Iowa* details the flight paths which track across Iowa.

Looking at landforms from a field sketch or from the remoteness of space tells us about their dimensions of form, pattern and distribution. To obtain a more thorough knowledge of landforms, we must look not only at their surface characteristics, but we must look *into* them—what kind of earth materials lie beneath the land to give form and durability to the surface. For example, the steep hills of extreme western Iowa are underlain by tens of feet of wind-blown silt. The poorly drained flatlands of north-central Iowa are underlain by glacial debris so "youthful" that streams have not had time to develop an integrated system for removing water from the area. The broad plains of the Mississippi River valley are underlain by alluvial sediments sorted and distributed by the meandering river and its periodic floodwaters. The rugged hills and valleys of northeastern Iowa are underlain by resistant sedimentary rock units of limestone and dolostone. Thus the answers to many of our questions about landform shape and landscape origins are tied to the types of materials found beneath their surfaces.

The interiors of landscapes can be examined where streams erode into hillsides or in quarries or road cuts where the sequence of earth materials is exposed by man. Because such exposures in Iowa generally are few and far between, much of our knowledge about the internal dimension of our landscapes is derived from drilling activity, such as water-well drilling, rock coring and testing for mineral resources, and research-oriented drilling projects (fig. 9). Data from drill sites are used to construct a three-dimensional picture of the types, thickness and distribution of glacier-, wind-, and stream-laid sediments, as well as the bedrock units that underlie the landscape. An important study of Iowa's landscape history using drill data was made by Robert V. Ruhe, formerly a soils geologist with the U.S. Department of Agriculture, Soil Conservation Service. The results of Ruhe's twenty years of field experience contributed to his volume *Quaternary Landscapes in Iowa*, published in 1969 by the Iowa State University Press.

There is one more important dimension in which landforms are examined—that of time. Landforms are continually undergoing change in response to natural processes at work—weathering, erosion, transportation and deposition by a variety of geologic agents—gravity, wind, water and ice. Landscapes have varied dramatically in their appearance from one period of geologic time to another. Consider, for example, that Iowa was once part of a vast sea in which lived great numbers of marine animals that we now find as fossils in the rocks. Or, that Iowa was once locked in a deep freeze by

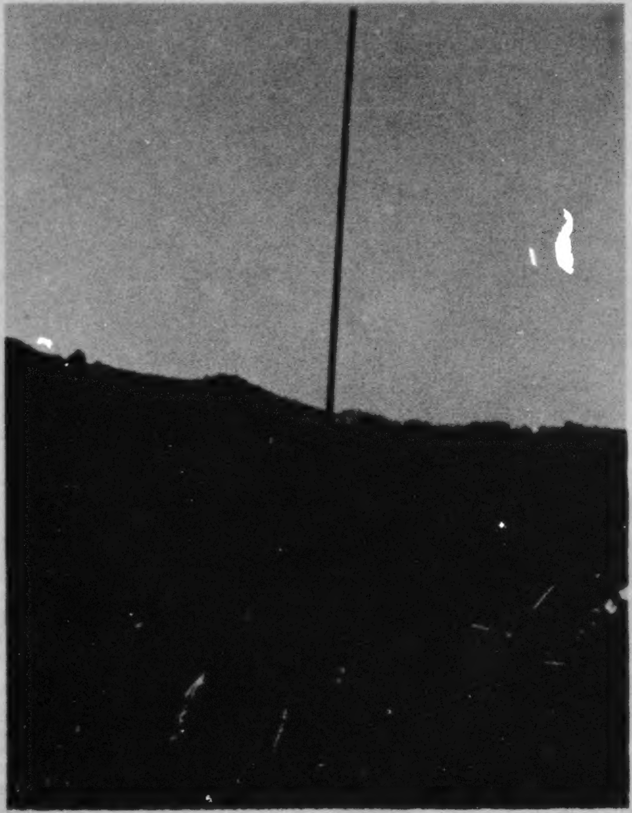


Figure 9. Drilling projects provide information on types of sediments that lie beneath the land surface. Here, along Waubonsie Creek in Fremont County, samples are taken to determine whether the sediments were deposited by the Missouri River, out of the picture to the right, or whether they originated from the loess hills in the background. Photo by James C. Davis.

hundreds, possibly thousands of feet of glacial ice. These strikingly different environments which existed in the state's geologic past were the result of very slow and individually small shifts in natural processes. The rate of change is extremely slow in terms of man's concept of time. The dramatic occurrence of a flood or a landslide we notice, but those processes that continue year after year, that gradually change the face of the land in the course of thousands or tens of thousands of years, we cannot casually sense. Thus, our tendency to think in terms of "the everlasting hills."

Geologic time is not clocked by equal time intervals such as minutes, hours or days. You may think of time as being measured in units of equal duration, but your personal view of time is more likely tied to major events which have been a part of your life such as birth date, educational milestones, marriage—events of unequal spacing and events to which we relate other, less important happenings. So it is that geologic time is measured by events of importance such as successions of volcanic eruptions, inundations by ancient seas, episodes of mountain building, evolution and extinction of prehistoric species, the expansion and melting of continental glaciers—events which form a set of reference points from which a story can be told.

Consider for a moment that the earth has been developing through about 4.5 billion years, as determined by *radioisotope dating* of meteorite fragments and lunar rock samples. The *basement*, or the crystalline rocks beneath Iowa, formed from molten materials that cooled following episodes of igneous activity. Radiometric analyses of these rocks yield dates as old as 1.1 billion years in Pocahontas County and 1.4 billion years in Dubuque County. After the formation of this foundation of igneous rocks, ancient shallow seas in which Iowa's sedimentary rock record developed, covered the state at various times, from approximately 600 million years to about 80 million years ago. Then, during the last 1.5 million years of our state's history, until about 13,000 years ago, the continental glaciers of the "Ice Age" waxed and waned over Iowa, and left behind much of the parent material from which our modern soils developed. Thus, in the perspective of geologic time and the events which mark its history, most of Iowa's landforms and the materials from which they have been molded are very "young." Glaciation is the most recent, significant geological event to which we can tie the story of Iowa landforms. This "Ice Age" period spans the portion of geologic time referred to as the *Pleistocene* or *Quaternary*.

To look at Iowa's landforms and Pleistocene events in more detail from the dimension of time, geologists utilize the *carbon-14* or radiocarbon method to date Pleistocene events within the past 40,000 years. Dating of organic carbon in the remains of plants and animals from different layers of earth materials can provide an absolute chronology for the Late Pleistocene events and deposits that shaped our modern landscape. Material for dating can be obtained from modern soils, ancient buried soils (paleosols), sediments deposited by glaciers, wind and water, skeletons of vertebrate fossils, shells, and carbonized remains of Paleo-Indian campfires (fig. 10). A partial listing of radiocarbon dates in Iowa may be found in Ruhe's book, *Quaternary Landscapes of Iowa*.

We are aware of the perspectives from which Iowa landforms are examined and have learned something of the techniques available for their study. We now are ready to discuss the events and processes associated with glaciation—that most recent and significant geologic event to which we tie the story of Iowa landforms.

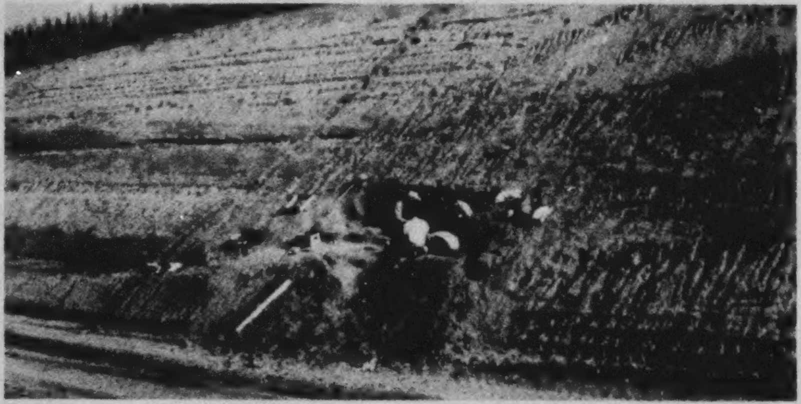


Figure 10. Road grading for County Hwy. G-42 west of Oakland, in Pottawattamie County unearthed the remains of a glacial-age mammoth. Here, a segment of tusk from this extinct, elephant-like creature is wrapped with wet-plaster bandages to protect the bone material from deterioration. Radiocarbon dating can be done on these vertebrate fossils to establish the age of the sediments enclosing them.

GEOLOGIC HISTORY AND MATERIALS OF IOWA LANDFORMS

> *"Slight as is this relief when compared with the mountains of Colorado, or the canyons of Arizona, it nevertheless comprises the various records of different geological agents acting through times almost inconceivable in their length. It possesses, therefore, an historic interest which may equal that of the most stupendous scenery. The historic interest of an ancient document does not depend on the size of its letters, nor are the geological values of the landscapes . . . lessened by the faintness of the characters in which their story is engraved."*
>
> —William H. Norton
> *Geology of Cedar County* (Iowa) 1901

It is a valuable and exciting experience to travel to new places, especially if we possess enough basic knowledge about the processes of landform evolution to be able to interpret the origins of the landscapes we see. So that we may start to look at Iowa landscapes with a more analytical eye, we will review the land-building and land-eroding processes that have left their marks on the face of Iowa.

The Upper Midwest is a gently rolling and fertile land unencumbered by the rugged mountain ranges, destructive subterranean quakes, steep-sided canyons or torrential waterfalls that characterize the more dramatic scenery of the Western mountain states. Iowa's land is characterized by low elevations, moderate relief, relatively flat-lying bedrock layers, rivers with many tributaries and a history of glaciation. Although glaciation is responsible for the subdued terrain, we will see that glacial processes and materials also gave a uniqueness to Iowa's landforms.

To understand the development of Iowa's present landscape, we must begin with the realization that Iowa has a buried landscape. We spoke earlier of the vast amounts of time that are recorded in the rock strata beneath Iowa's land, and of the dramatic variations in physical environments that have occurred through slow but continuous shifts in natural processes working through geologic time. We know that during many millions of years of Iowa's past, shallow seas covered all or parts of the state. Into these seas, rivers of the past carried particles of sand and clay eroded from even older rocks. Fragments of marine organisms and chemical precipitates from seawater also accumulated in these shallow basins. The sediment layers were compressed and hardened into sedimentary rocks such as sandstone, shale, limestone, and dolostone. The remains of ancient life forms that inhabited these seas were preserved as fossils in the hardening rock layers. This discussion leads to other interesting chapters in Iowa's geologic history, but for our purpose of looking at Iowa landforms, it is enough to realize that this accumulated sequence of sedimentary rock units underlies the entire state (fig. 11).

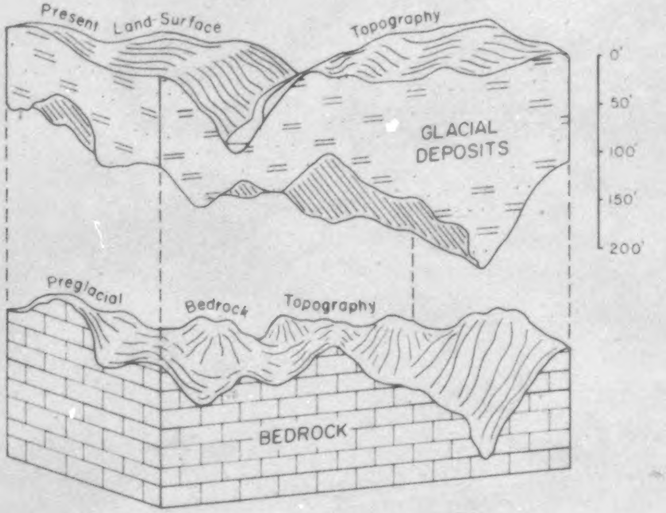


Figure 11. This block diagram demonstrates the relationship between the cover of unconsolidated glacial deposits and the older, sedimentary rock layers beneath. The topography developed on the bedrock surface in pre-glacial time does not usually coincide with Iowa's present landscape. Modified from Hallberg (1974).

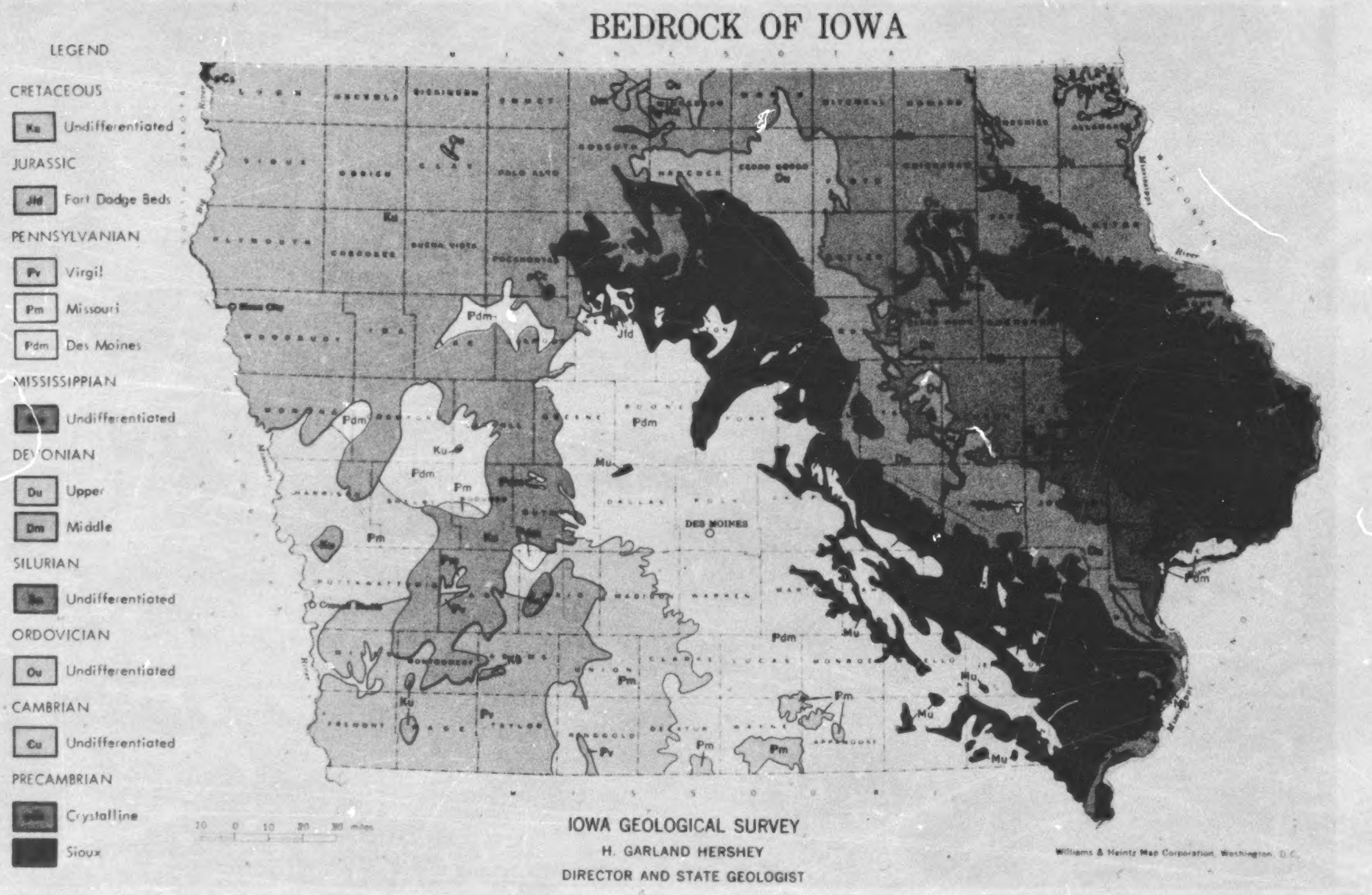

BEDROCK OF IOWA
LEGEND
CRETACEOUS
Ku Undifferentiated
JURASSIC
Jfd Fort Dodge Beds
PENNSYLVANIAN
Pv Virgil
Pm Missouri
Pdm Des Moines
MISSISSIPPIAN
Undifferentiated
DEVONIAN
Du Upper
Dm Middle
SILURIAN
Undifferentiated
ORDOVICIAN
Ou Undifferentiated
CAMBRIAN
Cu Undifferentiated
PRECAMBRIAN
Crystalline
Sioux
M I N N E S O T A
M I S S O U R I
DES MOINES
Pdm
Pm
Pv
Ku
Mu
Jfd
Cu
Dm
10 0 10 20 30 miles
IOWA GEOLOGICAL SURVEY
H. GARLAND HERSHEY
DIRECTOR AND STATE GEOLOGIST
Williams & Heintz Map Corporation, Washington, D.C.

Figure 12. BEDROCK GEOLOGY OF IOWA.

Across much of the state these rock layers are deeply buried beneath younger, glacially deposited sediments and thus have little influence on the surface landscape. At other places, such as northeast Iowa or elsewhere along the deeper river valleys, these bedrock units are exposed to view and may influence or even dominate the surface terrain. The geologic map (fig. 12) shows the distribution and stratigraphic age of Iowa's bedrock units.

These rock layers were subjected to erosion for a long period of time before the first great continental glacier spread across the state. Some faulting and regional warping of the rock layers occurred so that over much of Iowa they now are inclined or tilted slightly to the southwest and are quite fractured in places. However, the internal pressures of the earth were never great enough here to uplift mountains of the type we now see in the Rockies or the Appalachians. Rivers carved into these gently sloping rock strata and etched a landscape of steep valleys, sharp ridges and flat uplands, probably much like the present topography in the northeast counties of Iowa. This landscape which developed on the bedrock surface during pre-glacial time bears little resemblance, except in northeast Iowa, to the present shapes and distribution of hills and valleys seen in the "modern" Iowa landscape.

Then perhaps one and one-half to two million years ago, for reasons not totally understood, a shift occurred in the world's climatic heat balance. A slight decrease in the mean annual temperature and an increase in precipitation resulted in the accumulation of great thicknesses of snow and ice in parts of the Canadian Arctic. From these northern centers, sheets of ice hundreds, perhaps thousands, of feet thick spread outward under their own weight and reached across the North American continent from the Atlantic seaboard to the plains east of the Rocky Mountains. Several times during the Pleistocene Epoch these continental glaciers advanced over all or parts of Iowa and then melted away. The four principal periods of ice cover, in order of the oldest to youngest, are called the Nebraskan, Kansan, Illinoian and Wisconsinan glacial stages (fig. 13). They bear the names of the states where their most representative deposits occur and were studied by geologists of the last century. The times during which glaciers melted and ice-free conditions existed are called interglacial stages. These, too, were named for geographic areas where the deposits have their most representative occurrence. From the oldest to youngest, they are the Aftonian, Yarmouth, Sangamon and Holocene, or recent time, which geologists generally regard as being an interglacial stage (fig. 14). During each of these interglacial periods the climate returned to conditions more like those of today, and the glacial sediments were exposed to weathering, erosion and soil formation.

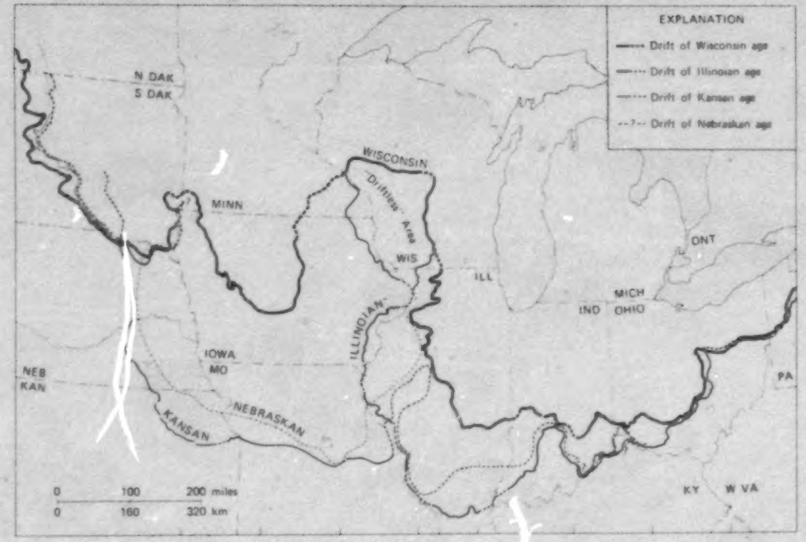


Figure 13. Known and inferred outer limits of four glacial stages in central North America. Reproduced by permission from Richard Foster Flint, *Glacial and Quaternary Geology*, 1971.

The glaciers of the Pleistocene spread slowly over Iowa's landscape, over the hills and valleys contoured earlier in the underlying bedrock. They scooped soil material and plucked rocks from their paths and carried them farther south. Much of this material was actually taken up and transported within the expanding ice mass, and eventually came to rest against the bedrock surface, lodged there by advancing ice or left behind by melting or stagnant ice. This

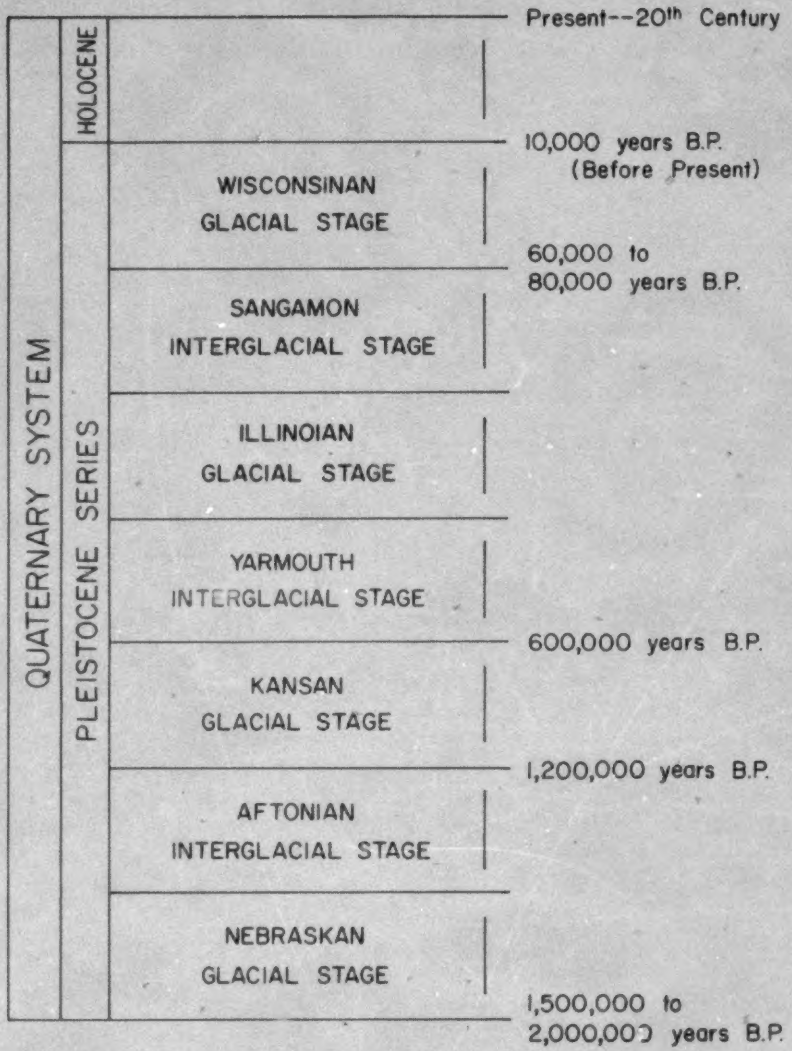

QUATERNARY SYSTEM
HOLOCENE
PLEISTOCENE SERIES
Present--20th Century
10,000 years B.P. (Before Present)
WISCONSINAN GLACIAL STAGE
60,000 to 80,000 years B.P.
SANGAMON INTERGLACIAL STAGE
ILLINOIAN GLACIAL STAGE
YARMOUTH INTERGLACIAL STAGE
600,000 years B.P.
KANSAN GLACIAL STAGE
1,200,000 years B.P.
AFTONIAN INTERGLACIAL STAGE
NEBRASKAN GLACIAL STAGE
1,500,000 to 2,000,000 years B.P.

Figure 14. Stratigraphic column of Quaternary System, listing the principal glacial and interglacial stages. Time horizons given for the stratigraphic order are determined on the basis of fossil vertebrate faunas and deep-sea cores.

unsorted, ice-transported sediment is called *till*, or *boulder-clay*—an admixture of clay, silt, sand and boulders, and often has wood or plant material incorporated within it. A more encompassing term, *drift*, sometimes is used to refer to all of the deposits, including till, that derived from glacial ice or its melted water. This blanket of glacial drift over Iowa varies in thickness from negligible in parts of northeast Iowa to recorded depths of over 600 feet in west-central Iowa.

Farmers in many areas of Iowa occasionally must clear boulders from their fields, only to find a season or two later that others have worked their way to the surface during winter's freeze and thaw. These boulders most frequently are igneous or metamorphic rocks and are conspicuous strangers in this state where sedimentary rocks are dominant. Consequently, they are called *erratics*. Such boulders may be traced back to native igneous and metamorphic bedrock units in Minnesota and Canada. The presence of these worn and weathered erratics in Iowa provides additional evidence of the power of moving ice and the direction from which the glaciers came.

The advancing sheets of glacial ice left even more detailed "tracks" which can tell the investigating earth scientist about ice movement and direction. Often, *glacial grooves* are observed where drift has been removed from the bedrock surface by stream erosion or by quarrying or construction activities (fig. 15). These parallel furrows were gouged into the bedrock as the glacial ice, dragging cobbles and boulders, inched across the rock surface. The direction of ice movement within the area may be determined from compass bearings taken along the grooves. These bedrock surfaces were literally planed by the ice, and their surfaces left very smooth to the touch and almost polished in appearance. Smaller grooves and scratches, or *striations*, and beveled surfaces also occur on areas of glaciated bedrock or on pebbles that were carried by the ice.

Some stream valleys were obliterated by the overriding ice, their waters deranged and diverted to form new channels. The old valleys were filled with drift that buried the former riverbeds far beneath the land surface. During melting, new streams were born from the margins of the ice, and they carried away tremendous volumes of water and sediment. These rivers surged in great floods during the summer months and covered miles of floodplain area. However,

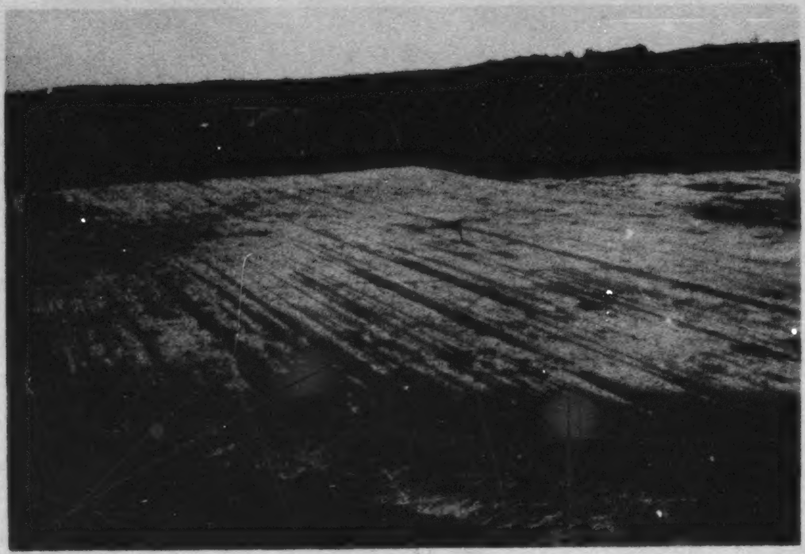


Figure 15. Unusually large display of glacial grooves inscribed on excavated limestone bedrock surface. Near East Peru, Madison County. Photo by Donald L. Koch.

during the winter, river volumes were reduced to a comparative trickle. As the seasonal floodwaters receded, they left broad expanses of floodplain covered with silty mud without any protective cover of anchoring vegetation. This silt was stirred by the westerly winter winds and clouds of dust were carried out over the changing Iowa landscape and deposited downwind of the contributing valleys. Each year this process was repeated until most of the ice-free portions of the Iowa landscape received a covering of the gritty, wind-carried sediments. These deposits are called *loess* and they form the parent material for many of the soil types that make Iowa's land so fertile. With the exception of north-central Iowa and a few other areas within the state, loess forms the last and most recent layer of material added during our Ice Age history. The thickness of loess deposits in Iowa varies from just inches to known depths of over 150 feet in Iowa's western counties adjacent to the Missouri Valley.

These river valleys which carried away the glacial meltwaters and served as sources of loess also carried large quantities of coarser glacial debris—sand and gravel, whose individual particles were too large and too heavy to be moved by wind or even very far at a time by water. As in all streams, water sorted the material that was available for it to carry. As water volumes and velocities changed with the seasons, large sheets of clay, silt, or sand and gravel were deposited along the valley *floodplains*. These water-sorted and water-deposited materials are called *alluvium* or *alluvial* deposits. When rivers renewed their down-cutting erosion cycles, new floodplain levels developed and remnants of the older floodplain surfaces were left at elevated positions within the valleys. These features are known as *alluvial terraces* and are usually separated from floodplain and other terrace levels by a distinct steep slope. Alluvial deposits reflect a sensitivity to water volume, velocity, and material available for transport. Therefore, alluvial terraces frequently are used by geologists to reconstruct fluctuations in glacial advance and retreat, changing climatic and vegetation conditions, and the corresponding, dramatic worldwide fluctuations of sea level that occurred during the Pleistocene.

As the Pleistocene ice sheets waxed and waned over Iowa's land surface and much of the Midwest, there were also distinct shifts in the distribution of plant and animal life. Forests of pine, spruce and fir, coniferous tree species that live today in the colder latitudes of the northern United States and Canada, extended to more southerly ranges as temperatures cooled, precipitation increased and the ice thickened and expanded southward. Such shifts in vegetation are documented by paleobotanists who study the fossil plant remains and pollen grains embedded in the sediments that accumulated in Pleistocene bogs and lakes (fig. 16).

Pleistocene-age sediments also yield remains of animal populations that inhabited Iowa's land during this interesting phase of landscape history. There are tiny white shells of terrestrial and aquatic snails, bones of various vertebrates including horse, camel, giant beaver, caribou, musk-ox, elk, sloth and bison, and the enormous teeth and tusks of woolly mammoths. Mammoths and mastodons, which now are extinct but resemble the modern elephant, are two of the better known large mammals that roamed North America during

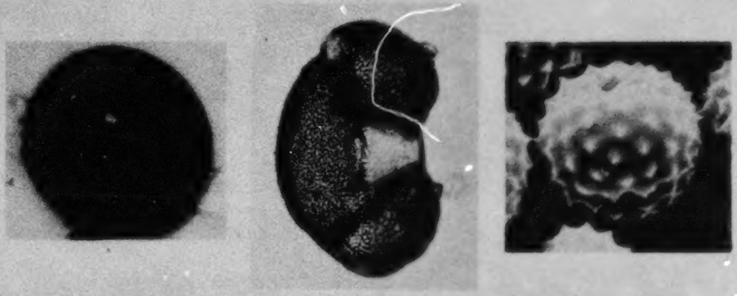


Figure 16. Microscopic views of pollen grains from glacial-age deposits provide a record of past vegetation and climate. At *left* is a pollen grain of Pleistocene grass (cf Gramineae) x 625; *middle* is a grain of Pleistocene pine pollen (*Pinus* sp.) x 500; and *right* is a modern ragweed pollen grain (*Ambrosia trifida*) x 1150 as seen through a scanning electron microscope. Photos by Richard G. Baker and Michael R. Burkart.

the glacial and interglacial stages. In Iowa, over 350 specimens of bones and teeth from these giants out of Iowa's geologic past have been documented, many from sand and gravel deposits along the state's stream valleys. Differences in tooth structure enable vertebrate paleontologists to distinguish between these two creatures and interpret something about their living habits. For example, the molar of the mammoth is composed of a series of laminated plates, having a gently ridged surface. This tooth structure, with its large grinding surface, indicates the mammoth was a grazing animal with a probable diet of grasses. The tooth of the mastodon, on the other hand, has numerous peaks or cusps, well adapted to browsing in timbered areas for their diet of tree branches, twigs, cones and leaves (fig. 17).

A particularly interesting discovery of the fossil remains of a mammoth was made in Pottawattamie County in 1970. A nearly five-foot segment of tusk, a lower third-molar, and other skeletal fragments, all from a single individual, were unearthed from the loess-covered uplands overlooking the West Nishnabotna Valley. This variety of material from the same individual indicated this upland landscape was the site of the animal's death—such a find is a rarity for mammoth remains thus far recovered in Iowa.

Nor was the mammoth found alone. The narrow, 18-inch fossil-bearing zone within the loess also yielded fossil teeth and jaw fragments of a snowshoe hare, meadow and heather voles, and red fox. The same species of small mammals live today, but generally north of the Minnesota-Canada border where the vegetation and climate are considerably different than experienced in Iowa today. Thus, this fossil assemblage provides a glimpse of Iowa's past climate and vegetation during the waning phases of the Wisconsinan glacial stage—colder with short, cool summers, and grasslands interspersed with stands of coniferous and deciduous trees.

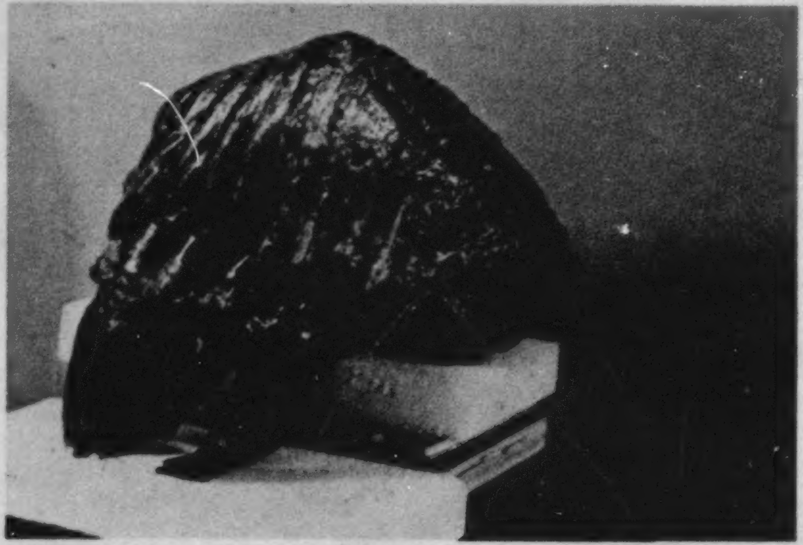


Figure 17. Comparisons of the sharp cusps of the mastodon (lower left) tooth structure with the flat grinding surface of the mammoth molar enable vertebrate paleontologists to interpret the diets and living habits of these large Pleistocene mammals. The mastodon browsed in timbered areas and the mammoth grazed the Pleistocene grasslands. Photo from Holmes A. Semken.

In our present interglacial environment, the principal agents at work on the landscape are running water, physical and chemical weathering, plants, and man. Precipitation falling on the land moves downslope and eventually is collected by one of Iowa's many streams. The water is channelled toward the sea where it evaporates into the atmosphere, and is available again as potential precipitation, thus completing the important *hydrologic cycle* (fig. 18). The once-glaciated landscape now is slowly but continuously being modified by stream erosion. The upland areas are being reduced in elevation; slope angles are steepening in some areas and declining in others; and the lowlands are accumulating materials brought to them by surface runoff and stream drainage.

Emerging through these great lengths of time and the changes brought by these natural events are the landscapes of Iowa that are familiar to us today. Only one other factor has altered the land's appearance—the activities of man. Before Iowa was settled, much of the land supported a natural prairie or grassland cover, with parts of the state dotted with numerous bogs and marshes. This original prairie vegetation grew in balance with factors of temperature and rainfall and cloaked Iowa in what was described by her earliest pioneers as literally, "a sea of grass" (fig. 19). There were fingering encroachments of forest along the river valleys and in the extreme northeast part of the state. Today only a few vestiges of native prairie remain, and many of the marshes and bogs or *"prairie potholes,"* have been drained. Most of the land surface is farmed and supports cultivated crops. The rich soils that developed in the loess, glacial tills and valley alluvium, plus the natural ability of the area to grow grasses, make Iowa a leading agricultural state, particularly in the production of grain crops such as corn and soybeans.

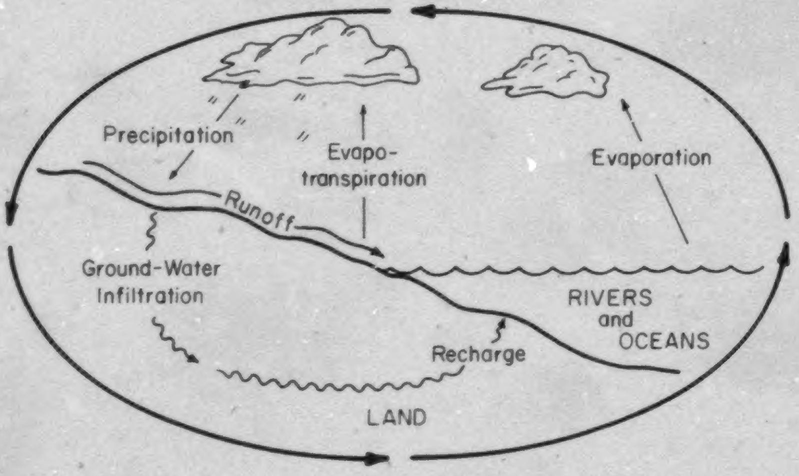


Figure 18. Schematic diagram of the hydrologic cycle, or water cycle, demonstrates the continual circulation of water from the sea, through the atmosphere, to the land, and the eventual return to the sea via rivers and again to the atmosphere by evaporation.

Figure 19. A remnant of Iowa's original, tall-grass prairie vegetation is protected in Hayden Prairie State Preserve in Howard County. This view, taken in May, shows native meadow wildflowers in bloom—the pale pointed shooting star of the Primrose Family and the yellow clustered puccoon of the Forget-Me-Not Family. Photo by Paul A. Christiansen.

It is important to note that all of the Pleistocene-age sediments—those deposited by the glaciers, by the streams that flowed from them and by the winds that blew across the region—are loose or *unconsolidated*, rather than consolidated like the bedrock units beneath. They are the materials in which our crops grow and from which we can draw water to drink or extract economic mineral resources. Even when we use bedrock wells, some replacement of the water we extract trickles downward through these sediments. We must know how these sediments, in combination with the surface topography, will be affected by the buried waste materials that are a product of our way of life, so that we can adequately protect our underground water resources. Some sediments provide natural protection for these subsurface *aquifers*, whereas others make pollution more probable. We must know how these sediments are distributed, how thick they are, over what kind of bedrock they lie, and the topography of that bedrock surface. These geologic factors can present assets or liabilities to human occupation and activity on the land's surface. Geological conditions should bear on the decisions men make as to how land will be used. Construction, mining, quarrying, waste disposal, suburban development, agricultural practices, the need for water—all these activities of our society require thoughtful consideration of the materials beneath the landscape.

We have been introduced to glacial processes which converted a rugged rock-dominated terrain into the fertile and rolling landscapes of Iowa, and we have acquired some terminology which will be useful in describing the materials which comprise Iowa's landscapes. We also have a feeling for the concept of geologic time as it relates to the state's landforms and an acquaintance with methods of looking at landforms. We are now ready to turn our attention to the details of Iowa's landform regions.

By observing the various types of terrain found in Iowa, we can divide the state into distinctive landform regions. Each region is distinguished from the others on the basis of its physical appearance. Some of the regions contrast sharply with adjoining regions and a distinct topographic boundary can be observed in the field. Other boundaries are less well defined and the change from one landform pattern to another may take place gradually over many miles. As indicated, many of the observable differences between regions are the result of variations in the glacial history of the area. Our emphasis will be on landform regions recognizable in the field, and the events of glacial history will serve as an aid to understanding what is observed.

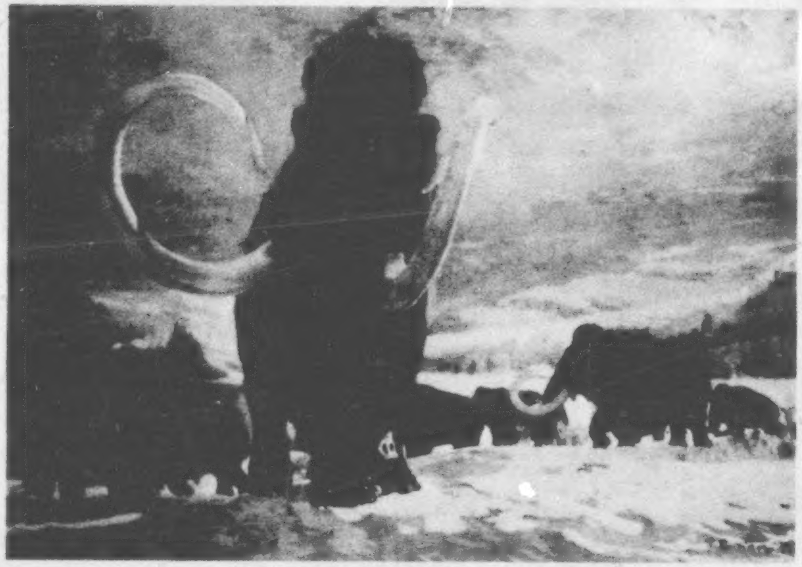


Figure 20. This excellent artist's view of the now-extinct woolly mammoth appears in *Prehistoric Animals* (1956) by J. Augusta and Z. Burian, Spring House, London. Reproduced with permission of The Hamlyn Group Picture Library, Feltham, England.

LANDFORM REGIONS OF IOWA

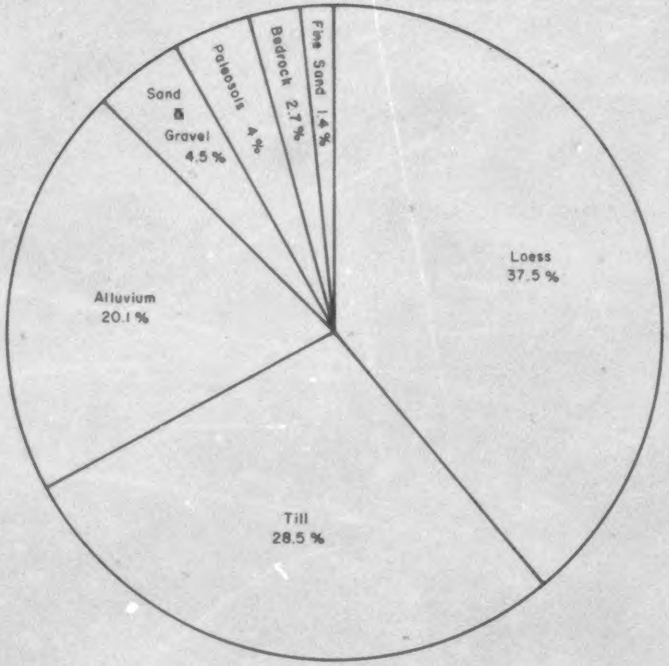


Figure 21. SURFICIAL MATERIALS OF IOWA.

Iowa contains 55,986 square miles. The eastern border with Illinois is drawn along the Mississippi River. The western border with Nebraska and South Dakota is drawn along the Missouri and Big Sioux Rivers, respectively. The northern border with Minnesota nearly coincides with parallel 43°30′ North latitude, and the southern boundary with Missouri is an arbitrated line that approximates the arc of parallel 40°35′ North latitude eastward to the Des Moines River and then follows the river's course southeast to the Mississippi.

The rolling, agriculturally dominated landscape is characterized by low elevations, moderate relief, gently inclined bedrock layers, numerous rivers, fertile soils and a history of glaciation. The highest point in the state has an elevation of 1,670 feet above sea level and is located in northwest Iowa's Osceola County. The elevation of the state's lowest point is 480 feet above sea level, located in southeast Iowa at the confluence of the Des Moines and Mississippi Rivers.

The map on the facing page identifies the landform regions of Iowa. It is followed by a series of supporting maps that contain information on the state's rivers and lakes, elevations, glacial history and topographic relief. These maps are followed by discussions on the individual landform regions. The Paleozoic Plateau, Western Loess Hills, and Alluvial Plains are described first because of their distinct, easily recognized landscapes and their relatively independent and uncomplicated geologic histories. The next four regions, the Des Moines Lobe, Southern Iowa Drift Plain, Iowan Surface and Northwest Iowa Plains are presented in sequence because, like their geomorphic history, the understanding of each develops from discussion of the previous regions.

The diagram at left graphically represents the relative amounts of earth materials present over Iowa's land surface. This information was prepared by George R. Hallberg of the Iowa Geological Survey from modern soil-survey data.

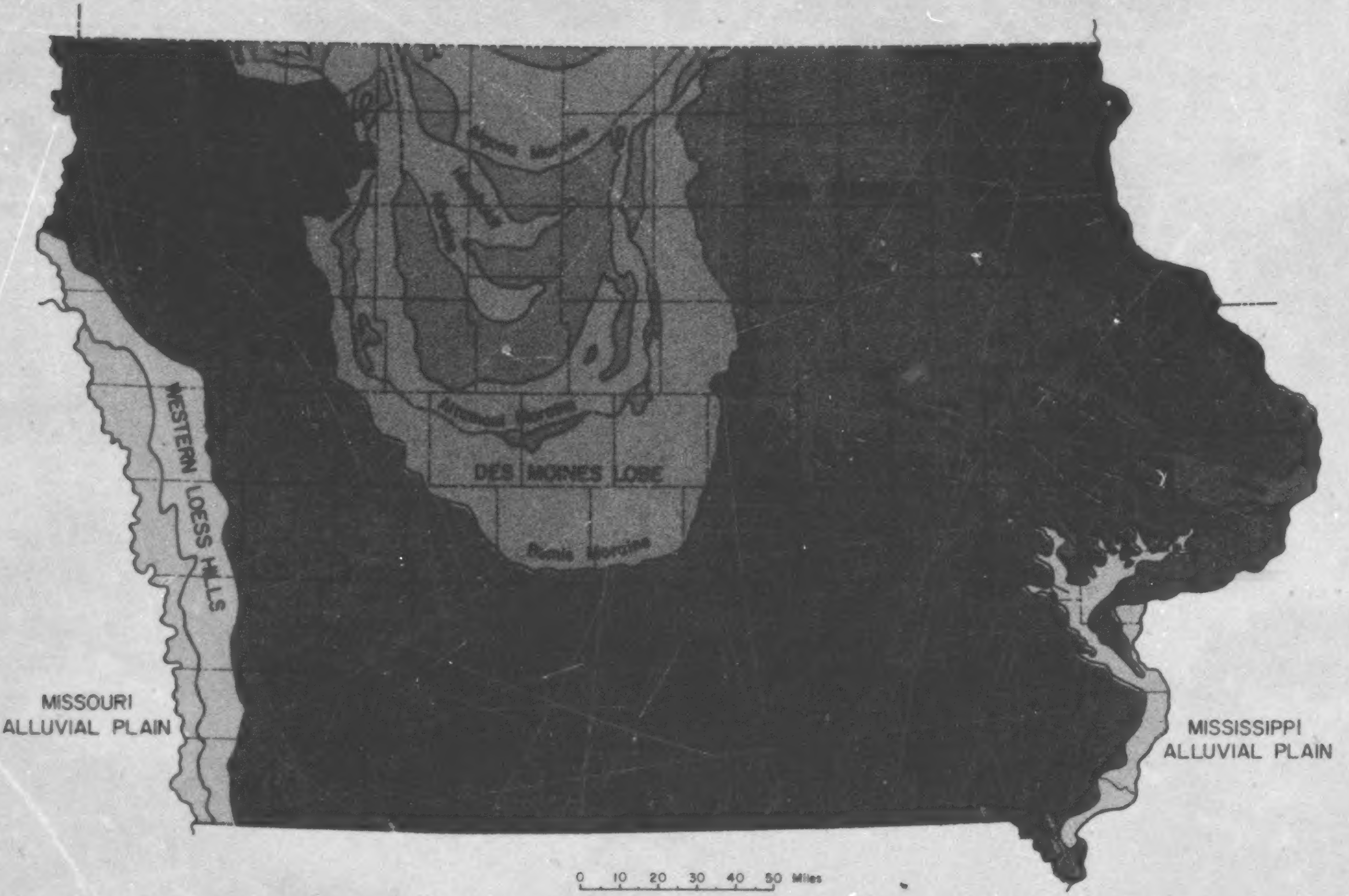

Algona Moraine
Altamont Moraine
DES MOINES LOBE
Bemis Moraine
WESTERN LOESS HILLS
MISSOURI
ALLUVIAL PLAIN
MISSISSIPPI
ALLUVIAL PLAIN
0 10 20 30 40 50 Miles

Figure 22. LANDFORM REGIONS OF IOWA.

Iowa Geological Survey
1976

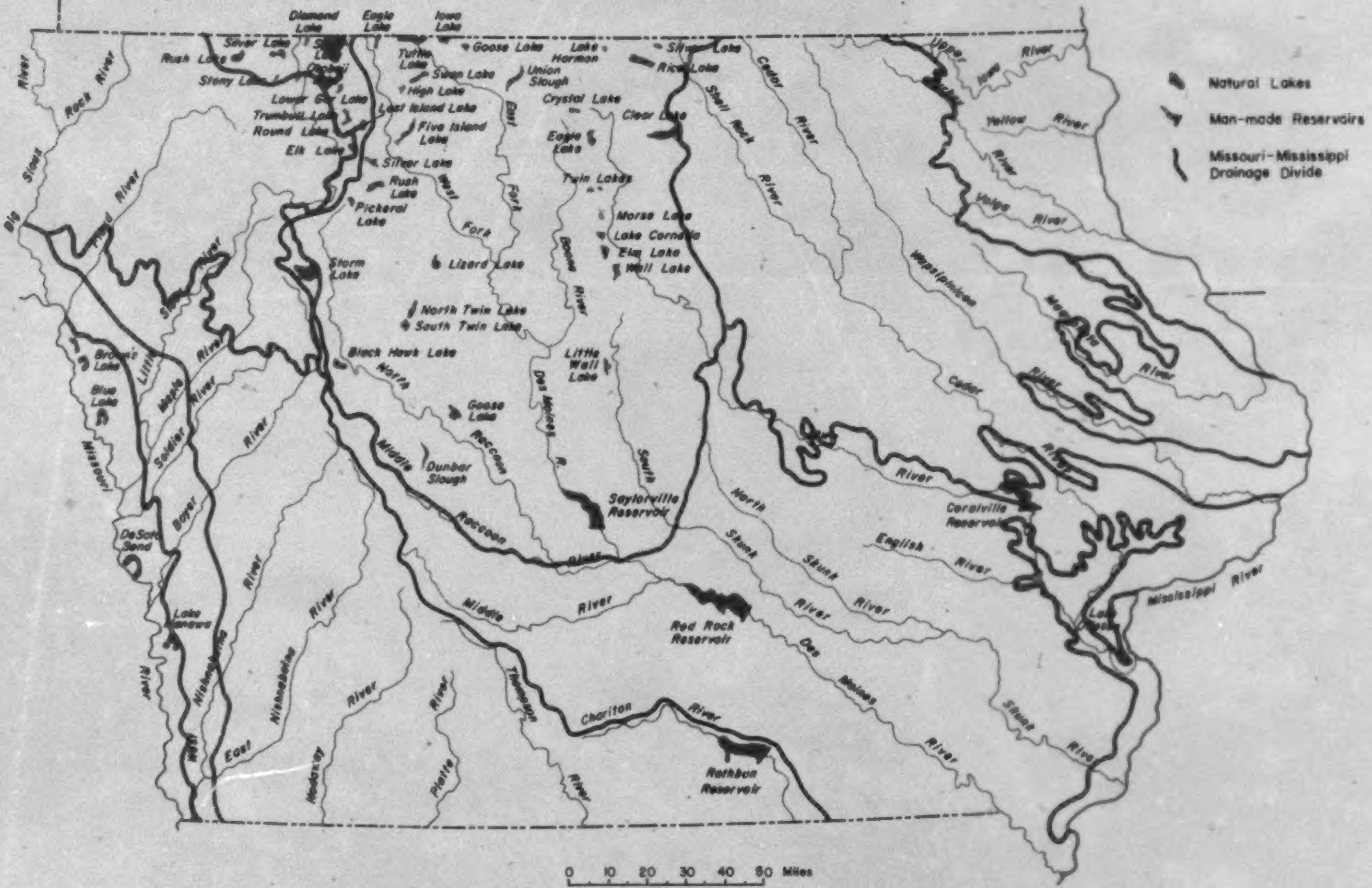

Diamond Lake
Eagle Lake
Iowa Lake
Silver Lake
Spirit Lake
West Okoboji
Rush Lake
Stony Lake
Lower Gar Lake
Trumbull Lake
Round Lake
Elk Lake
Turtle Lake
Swan Lake
High Lake
Lost Island Lake
Five Island Lake
Silver Lake
Rush Lake
Pickerel Lake
Storm Lake
Goose Lake
Lake Harmon
Union Slough
Crystal Lake
Silver Lake
Rice Lake
Clear Lake
Eagle Lake
Twin Lakes
Morse Lake
Lake Cornelia
Elm Lake
Wall Lake
Lizard Lake
North Twin Lake
South Twin Lake
Black Hawk Lake
Little Wall Lake
Goose Lake
Dunbar Slough
Saylorville Reservoir
Red Rock Reservoir
Rathbun Reservoir
Coralville Reservoir
Browns Lake
Blue Lake
DeSoto Bend
Lake Manawa
Rock River
Big Sioux River
Floyd River
West Fork
East Fork
Little Sioux River
Maple River
Soldier River
Boyer River
Missouri River
West Nishnabotna
East Nishnabotna
Nodaway River
Platte River
Thompson River
Chariton River
Boone River
Des Moines R.
Des Moines River
North Raccoon
Middle Raccoon
South Raccoon
Raccoon River
Middle River
North Skunk
South Skunk River
Skunk River
English River
Iowa River
Cedar River
Shell Rock River
Wapsipinicon River
Maquoketa River
Turkey River
Volga River
Yellow River
Upper Iowa River
Mississippi River
Natural Lakes
Man-made Reservoirs
Missouri-Mississippi Drainage Divide
0 10 20 30 40 50 Miles

Figure 23. RIVERS AND LAKES OF IOWA.

Iowa Geological Survey
1976

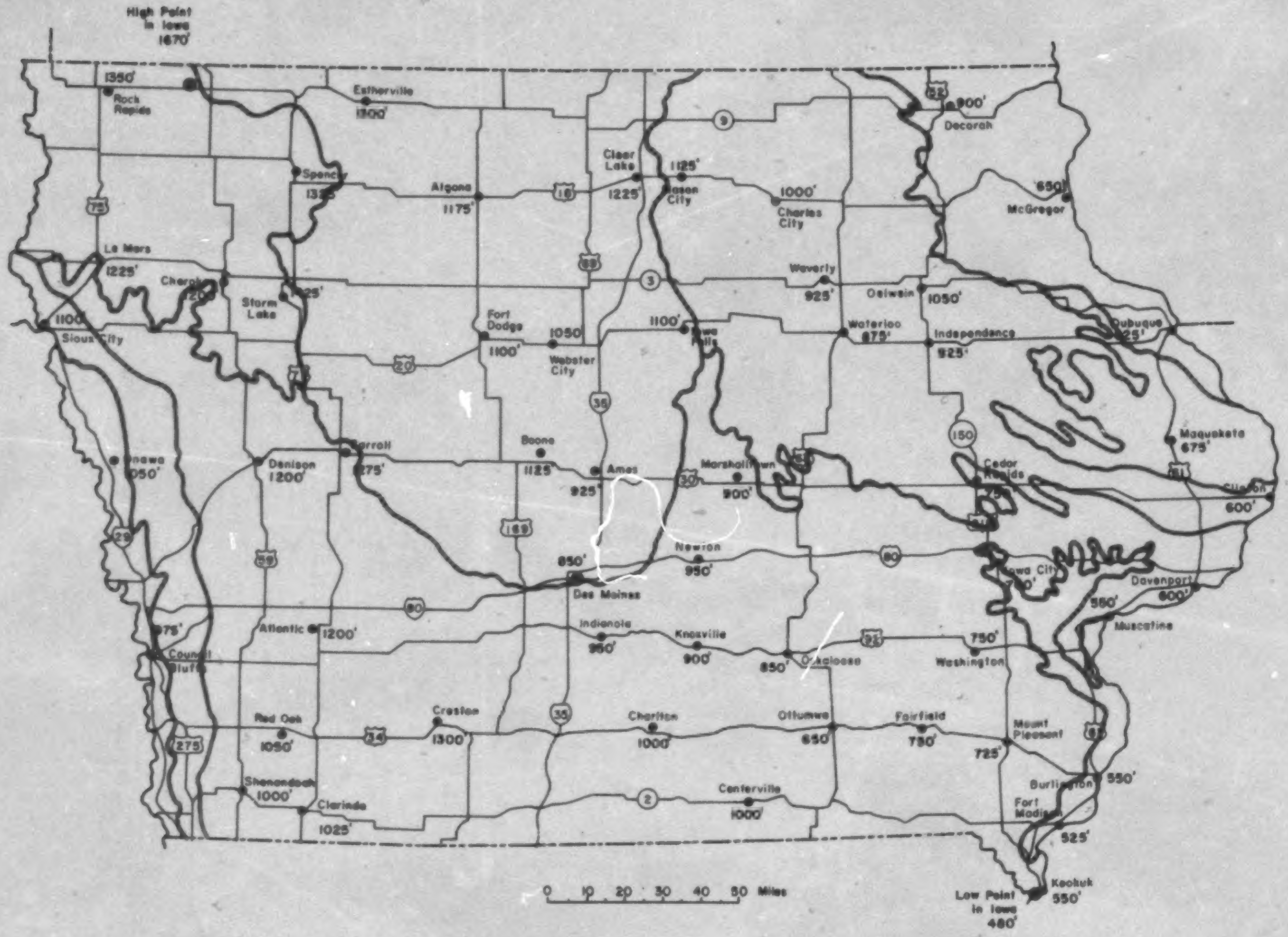

High Point in Iowa 1670'
1350'
Rock Rapids
Estherville
1300'
Spencer
Algona
1175'
Clear Lake
1225'
1125'
Mason City
1000'
Charles City
900'
Decorah
650'
McGregor
Le Mars
1225'
Cherokee
Storm Lake
1100
Sioux City
Fort Dodge
1100'
1050
Webster City
1100'
Iowa Falls
Waverly
925'
Oelwein
1050'
Waterloo
875'
Independence
925'
Dubuque
Maquoketa
675'
Clinton
600'
Onawa
1050'
Denison
1200'
Carroll
1275'
Boone
1125'
Ames
925'
Marshalltown
900'
Cedar Rapids
850'
Des Moines
Newton
950'
Iowa City
Davenport
600'
550'
Muscatine
975'
Council Bluffs
Atlantic
1200'
Indianola
950'
Knoxville
900'
850'
Oskaloosa
750'
Washington
Red Oak
1050'
Creston
1300'
Chariton
1000'
Ottumwa
650'
Fairfield
750'
Mount Pleasant
725'
Burlington
550'
Shenandoah
1000'
Clarinda
1025'
Centerville
1000'
Fort Madison
525'
Keokuk
550'
Low Point in Iowa 480'
0 10 20 30 40 50 Miles
75
18
69
3
9
52
20
71
35
169
59
29
30
150
61
80
34
275
92
2
218
65

Figure 24. ELEVATIONS IN IOWA.

Iowa Geological Survey
1976

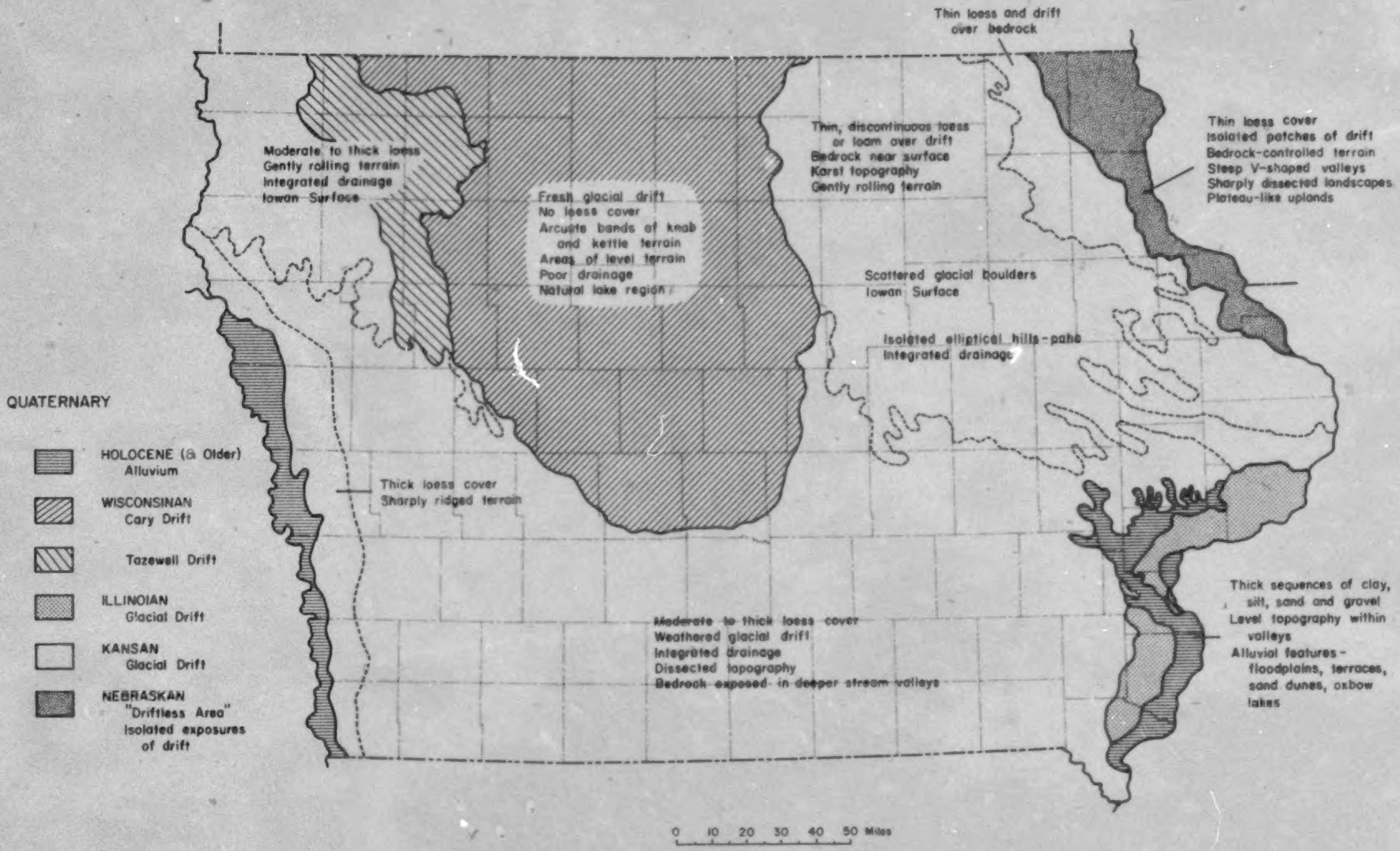

Thin loess and drift over bedrock
Moderate to thick loess
Gently rolling terrain
Integrated drainage
Iowan Surface
Fresh glacial drift
No loess cover
Arcuate bands of knob and kettle terrain
Areas of level terrain
Poor drainage
Natural lake region
Thin, discontinuous loess or loam over drift
Bedrock near surface
Karst topography
Gently rolling terrain
Thin loess cover
Isolated patches of drift
Bedrock-controlled terrain
Steep V-shaped valleys
Sharply dissected landscapes
Plateau-like uplands
Scattered glacial boulders
Iowan Surface
Isolated elliptical hills-paha
Integrated drainage
QUATERNARY
HOLOCENE (& Older) Alluvium
WISCONSINAN Cary Drift
Tazewell Drift
ILLINOIAN Glacial Drift
KANSAN Glacial Drift
NEBRASKAN "Driftless Area" Isolated exposures of drift
Thick loess cover
Sharply ridged terrain
Thick sequences of clay, silt, sand and gravel
Level topography within valleys
Alluvial features - floodplains, terraces, sand dunes, oxbow lakes
Moderate to thick loess cover
Weathered glacial drift
Integrated drainage
Dissected topography
Bedrock exposed in deeper stream valleys
0 10 20 30 40 50 Miles

Figure 25. QUATERNARY TERRAIN AND MATERIALS IN IOWA.

Iowa Geological Survey
1976

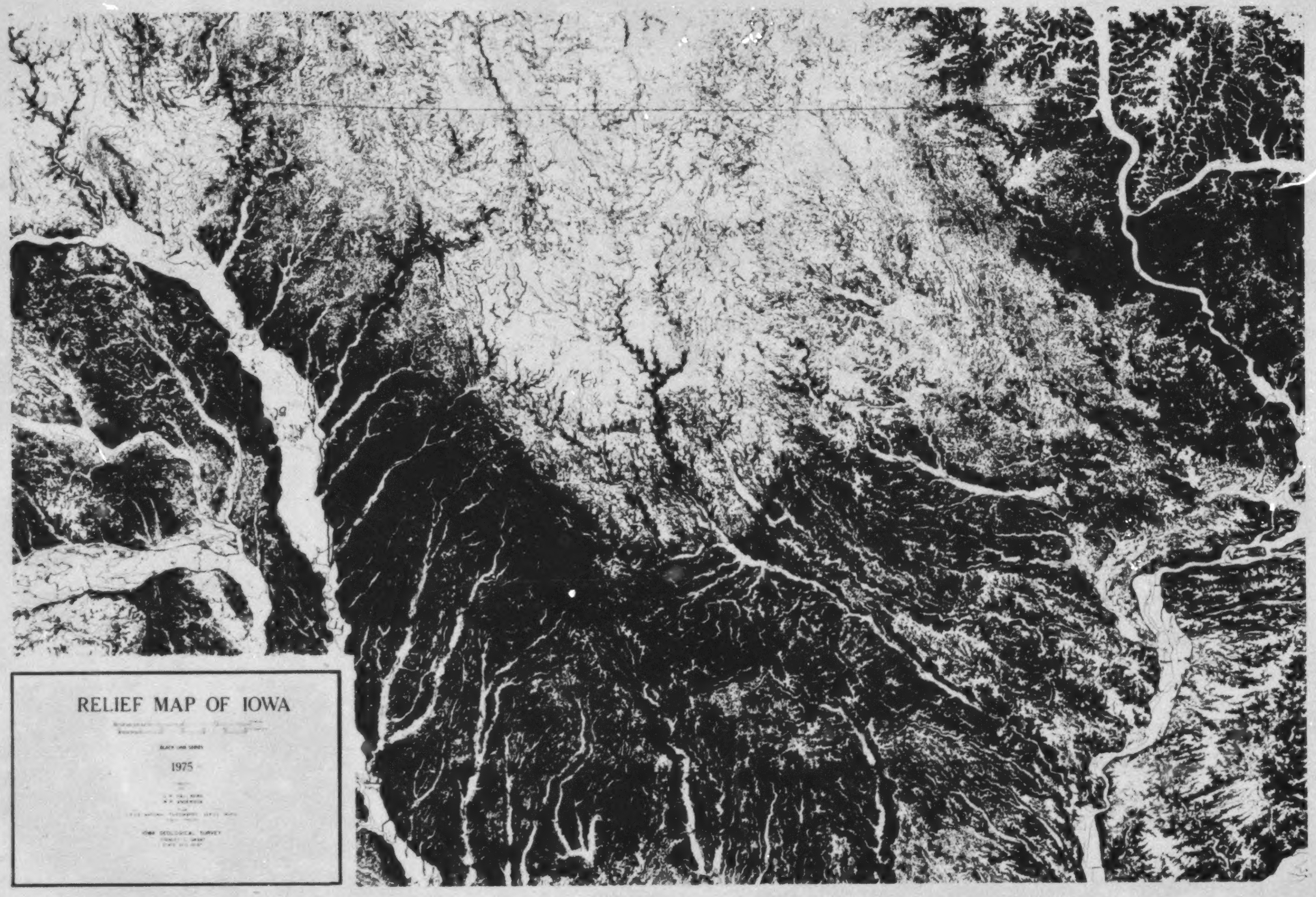
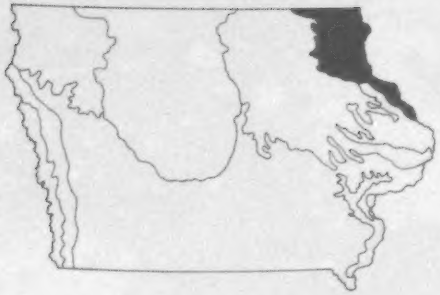

RELIEF MAP OF IOWA
1975
IOWA GEOLOGICAL SURVEY

Figure 26. RELIEF MAP OF IOWA.



PALEOZOIC PLATEAU

28

"To the traveler who has previously been acquainted with the topographic forms of Iowa only as they are developed in the drift-covered portions of the state, the extremes of relief and the intricacies and peculiarities of the topography. . . come in the nature of a surprise. The deep valleys, the high bluffs, the water-carved ridges, every topographic form, indeed, are each and all wholly unique, for the other parts of the state furnish nothing with which they can in any way be compared. The gorges, canyons with high, frowning walls, dome-like hills, and other peculiarities which the region presents, have led with much reason to speaking of. . . "The Switzerland of Iowa."

—Samuel Calvin
Geology of Allamakee County (Iowa) 1895

Scenic landscapes of unexpected proportions exist in extreme northeastern Iowa. In comparison with other regions of the state, the topography here is unusually rugged and the area is referred to popularly as "Little Switzerland." Deep valleys, abundant rock outcrops, high bluffs, caves, crevices, sinkholes and an angular, stepped skyline are characteristic elements of the terrain.

In terms of geologic time, this northeastern Iowa landscape has been exposed to weathering and erosion longer than any other region of the state. In fact, for many years the eastern half of this region was thought to be completely untouched by the Pleistocene glaciers, and was referred to by geologists as the "Driftless Area" (fig. 25), which also included similar, adjoining terrain in northwest Illinois, southwest Wisconsin and southeast Minnesota. We now know that thin, isolated patches of drift, probably of Nebraskan age, do exist in the Iowa portion of this area that once was considered unglaciated. However, throughout the region designated here as the Paleozoic Plateau, the influence of glacial drift and loess on the landscape is minimal, and the terrain is dominated by Silurian, Ordovician and Cambrian (Paleozoic) rock formations (figs. 12, 27). This is the only region in Iowa where bedrock so completely controls the surface form of the land.

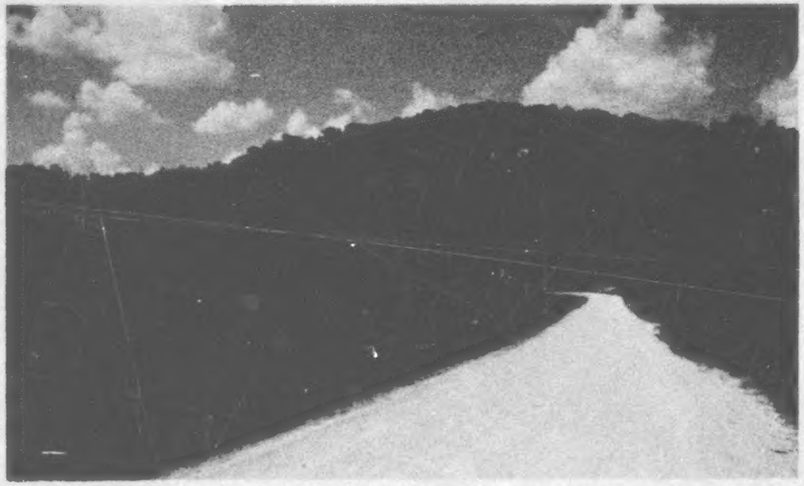


Figure 27. Outcrops of Paleozoic-age limestone in eastern Allamakee County between Lansing and Harpers Ferry show that the form of the land surface is controlled by underlying bedrock formations.

Surface drainage is eastward toward the Mississippi and is accomplished primarily by the Upper Iowa, Yellow, Turkey and Volga Rivers. These streams and their tributaries have cut deeply into the land exposing sedimentary rock layers of limestone, dolostone, sandstone and shale. Resistant rock outcroppings, such as limestone or dolostone, in the channels of these steep-gradient streams result in rapids along some of the water courses. Stream valleys are deep, narrow and V-shaped in profile, with irregular slopes and steep cliffs. Often, the valleys take abrupt, sharp-angled turns, indicating the local drainage network is controlled by *joint* patterns in the underlying bedrock (figs. 29, 30). Streams eroding in less resistant rock units, such as shale, have developed wider valleys with smoother and gentler slopes. Often it is possible to look out across the landscape and identify the positions of discrete rock formations on the basis of how they influence the appearance of the land.

The topography in the portion of the region nearest the Mississippi River is particularly striking. Numerous streams and small creeks spill out of the uplands into the Mississippi Valley and accentuate the dissected appearance of this area. Coming out of these narrow, confining valleys, the view expands in all directions, and the eye can trace distinct upland levels across the landscape. These flat, uniformly level summits are remnants of a once-continuous land surface, now excavated by the erosive power of streams. These levels are joined to each other and to the major river floodplain surfaces by steep *escarpments*, and thus provide the distinctive plateau appearance to this part of Iowa (fig. 28).

Traveling toward the western margin of the region, the angular plateau appearance of the landscape gives way to a more rolling terrain, but one still dominated by bedrock patterns. The presence of Wisconsinan loess, the addition of Kansan-age glacial till and the increased exposure of shale formations, in contrast to the more resistant rock types to the east, account for the more rounded contours. However, the terrain is still highly dissected and contrasts sharply with the glacial drift plains to the west and south. In addition, much of the western and southern boundary of this region coincides

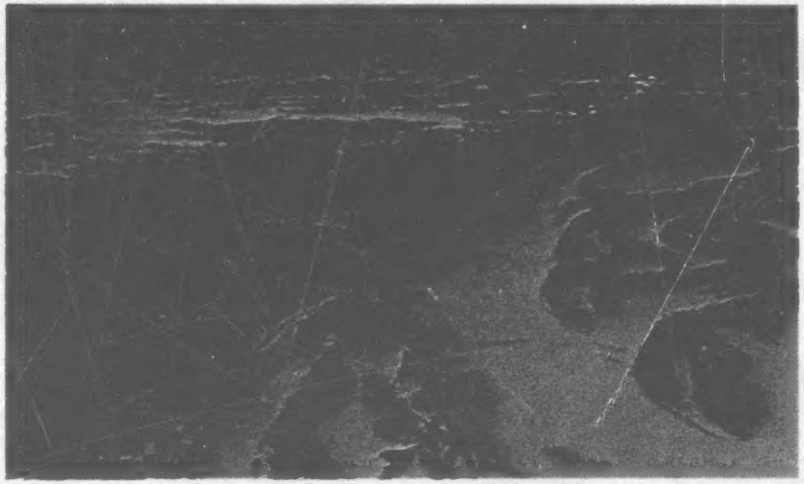


Figure 28. This February aerial photograph shows a steep narrow tributary valley entering the ice-covered Mississippi River in southeast Allamakee County. Note the distinctive plateau appearance of the landscape, the mural-like exposures of bedrock along the bluffs facing the Mississippi Valley, the braided river channels within the broad valley, and the V-shaped profile of the tributary stream accentuated by stands of coniferous trees.

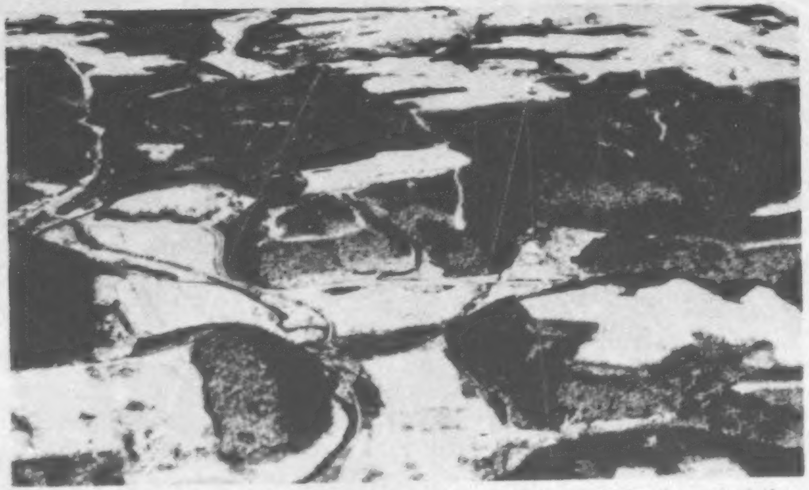


Figure 29. Sharp-angled joint patterns in the underlying bedrock control the surface drainage network along this segment of the Yellow River in southeast Allamakee County. Note the abrupt, almost right-angle turns of the river channel and the similar angularity of tributary stream valleys.

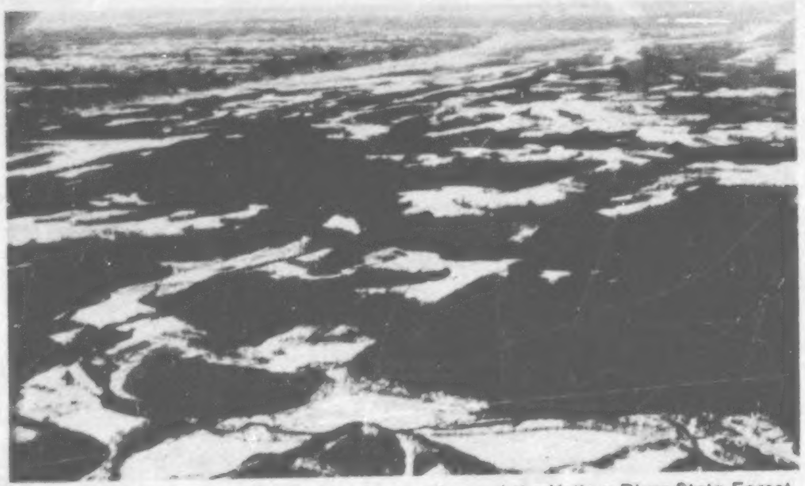


Figure 30. A winter aerial view across portions of the Yellow River State Forest to the Mississippi Valley and southeast to Prairie du Chien, Wisconsin, illustrates V-shaped valley profiles, angular drainage patterns, and the outcropping rock ledges that defend the plateau surface.

with a segment of another prominent physiographic feature known as the Niagara Escarpment (figs. 22, 12). This escarpment is formed by the outcrop pattern of the Niagaran Dolomite, a particularly resistant Silurian-age rock formation which can be traced through several states east of Iowa and which takes its name from its most famous effect on the landscape—Niagara Falls, New York.

Carbonate rocks such as limestone and dolostone can be dissolved by long contact with surface streams (fig. 31) and ground water. Subterranean voids can develop in these rocks as water moves along joints and fractures or other zones of weakness. Thus, when carbonate formations exist close to the land surface, these subterranean processes and features often affect the landscape. The results are caves, crevices, springs, and *sinkholes*, or circular depressions at the land surface formed by undermining and collapse of surface materials into these underground voids. A landscape exhibiting such features is an example of *karst* topography. Karst features in Iowa are not restricted to the Paleozoic Plateau, but they frequently occur in this region when the near-surface bedrock is limestone or dolostone.

One of the most spectacular karst features in Iowa is Cold Water Cave, east of Kendallville in Winneshiek County. Illuminated by the beam from a miner's lamplight, this dark and damp serpentine passage comes alive with colorful flowstone formations and glistening stalactites and stalagmites (fig. 32). Water rushes over the irregular rock floor, around huge slabs of ceiling breakdown, and swirls through deep potholes on its way to the grassy meadow where Cold Water Spring issues from beneath a towering limestone bluff. This example of subterranean drainage, fed by the infiltration of surface water through sinkholes, creating unique underground environments of cave *speleothems*, and finally returning again to the land surface is a classic example of karst development.

Quarries are common in the limestone and dolostone formations throughout this region. The rock is used primarily for road construction and maintenance, though some is quarried for building stone. In addition to the value of this material as an economic mineral resource, many wells are drilled into these carbonate rocks for drinking water supplies. The karst characteristics of the area should

Figure 31. Turner Creek cuts into a portion of the Silurian-age Niagara Escarpment in Fayette County northwest of West Union. The small waterfall and plunge pool are characteristic features in this area of resistant bedrock, high-gradient streams, and karst development. Photo by Donald L. Koch.

Figure 32. Cold Water Cave in Winneshiek County is an excellent example of karst development. Here, in a section termed "The Gallery," colorful speleothems of massive flowstone and intricate draperies decorate the north wall. The flat, cave ceiling is criss-crossed with joint fractures in the Galena limestone. The trail of light is from a miner's lamp worn by the person moving downstream during this time-exposure. Photo by Jay Hytone.

be a reminder that contaminants from the land surface have easy access to the subsurface water-bearing zones, and care must be taken with waste disposal to prevent pollution of these important underground aquifers.

This northeastern region also contains a large share of Iowa's natural woodlands. The steep and rocky slopes are unsuitable for cultivation and thus have retained their native forest cover. With cropland at a premium in many areas, the small but productive floodplains and terraces in the valley bottoms are intensively cultivated. The upland flats also are cultivated or used as pasture, particularly for dairy cattle.

The rugged topography lends itself to many types of outdoor recreation, both winter and summer. Trout fishermen seek the quiet pools along the numerous streams, and canoe enthusiasts can travel many miles of wooded and rock-bound waterways. The heavily timbered landscape supports a colorful autumn foliage, and with the snow-covered slopes in winter, the region attracts many visitors each year (fig. 33).

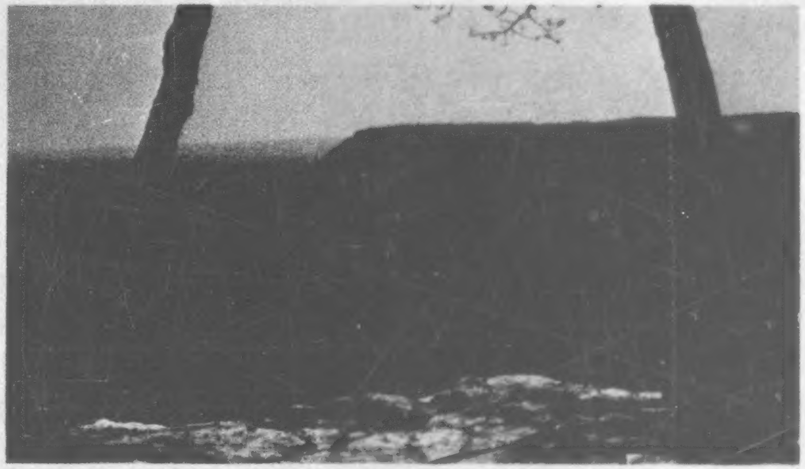
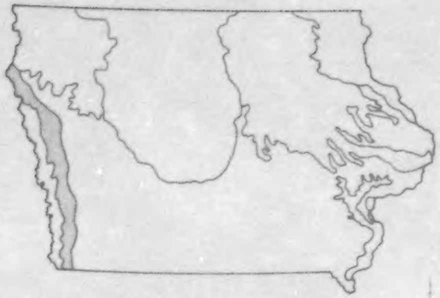
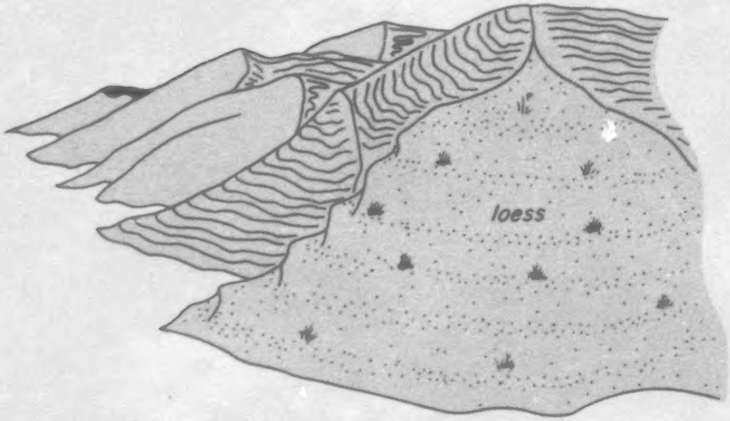


Figure 33. This scenic view of the Mississippi River valley and its junction with the valley of the Wisconsin River is seen by many visitors to Pikes Peak State Park, near McGregor in Clayton County.



> *"In the spring when abundant rains have bathed the rugged slopes, an almost uniform green suffuses them; in early summer they are brilliant with loco weed and other flowers; but when summer has advanced, when the rains have ceased and the blistering winds and scorching sun have robbed the southwesterly prairie slopes of their moisture, the sheltered groves and the exposed prairie surfaces stand out in sharp contrast, visible for many miles and setting out with striking effect and unmistakable precision the varied features of this singular topography."*
>
> —Bohumil Shimek
> *Geology of Harrison*
> *and Monona Counties*
> (Iowa) 1910

WESTERN LOESS HILLS



Extending north and south along the bluffs that border the Missouri River valley is a narrow zone of some of Iowa's most unusual terrain (figs. 22, 34). West of this bluffline lay miles of flat lowlands of the Missouri River's wide floodplain. Prevailing westerly winds sweep unhindered across this flat expanse until abruptly checked by the rise of uplands marking the east side of the river valley. The topographic obstacle created by this steep valley wall causes turbulence and shifts in wind currents.

As the Pleistocene glaciers melted, the Missouri Valley became a major channelway for tremendous volumes of water and sediment released by the melting ice. Each winter season the quantity of meltwater was reduced considerably, and large areas of flood-deposited sediments were left exposed to the wind. Silt, clay and fine sand were lifted into great clouds of dust and carried downwind to the east. As these silt-laden winds encountered the steep slope of the east valley wall, their air currents broke formation and the silty loads were dropped, in much the same manner as snowdrifts pile up behind a snow fence. The material that accumulated in western Iowa during Illinoian time is known as Loveland Loess, and that which was added during Wisconsinan time is Peorian or Wisconsin Loess. As with other geologic formations, these deposits are now identified by the geographic localities (one in Iowa and one in Illinois) where they were originally described and studied. Radiocarbon

Figure 34. An aerial photograph taken near the Harrison-Monona County line shows the sharp break in topography between the flat lowlands of the Missouri River valley and the steep slopes and intricate ridges of the Western Loess Hills. This unique terrain is developed totally within the thick deposits of loess.

dating of loess deposits in Iowa show that major deposition of loess ceased about 14,000 years ago. Even though these optimum environmental conditions for loess deposition no longer exist in the state, the dry "Dust Bowl" years of the 1930's, or the yellowish-brown haze filtering the sun on a windy day during spring plowing remind us of the continuing ability of the wind to move materials.

This process of loess accumulation during the Pleistocene took place in varying degrees along most major river valleys in the Midwest. The result was a mantle of loess over much of the intervening land area, with particularly thick deposits on the east or leeward side of contributing valleys. However, along the Missouri Valley bluffs, in western Iowa, this loess accumulated in such proportions that a unique landscape developed. Only in the corresponding latitudes of China does a similar landscape exist anywhere in the world. Water wells drilled in this area of western Iowa frequently penetrate thicknesses of loess in excess of 150 feet, and a few wells indicate deposits over 200 feet thick. Here, loess is not just a cover, mantling landforms developed in glacial till or in bedrock. Instead, the loess is of such thickness to give basic form and substance to the land surface. The intricate angularity of the ridges and ravines seen today is the result of subsequent erosion by streams into the uniform, fine-textured sediments.

The most prominent bluffs and ridges of the Western Loess Hills are directly adjacent to the Missouri River valley and extend eastward for distances of three to twenty miles. The landscape has a corrugated appearance of alternating waves and troughs (fig. 35). Hills are sharp-featured, with narrow broken ridge-crests, intersecting spurs and steep sideslopes. These deposits of quartz silt are loosely compacted and porous, light in weight, and quite cohesive when dry. These characteristics enable loess to maintain nearly vertical slopes where deeply eroded, as well as the steep angles seen in roadcuts throughout the region. A striking feature of many of the steeper slopes is a uniformly terraced and step-like appearance. These *catsteps* are a natural phenomenon resulting from repeated slipping and downslope movement of loess (fig. 36).

Figure 35. This well-defined segment of the Western Loess Hills between the Missouri and Maple River valleys in Monona County shows the sharp-featured hills, narrow ridge crests, intersecting spurs and steep sideslopes that result from stream erosion of the uniform-textured deposits of windblown silt.

Figure 36. A close-up aerial view of the steep sideslopes of a loess ridge reveal a stepped or terraced appearance. These "catsteps," as they are called, are a natural phenomenon and result from repeated slippage and downslope movement of loess.

On closer examination, loess feels gritty and is usually tan, yellowish-brown, yellowish-orange, or light gray in color. Coloration may be quite uniform or strongly mottled. Some exposures of loess in this area contain hard, nodular pebbles known as *loess kindchen.* These nodules vary greatly in size and shape and are concretionary accumulations of lime that formed in the loess after it was deposited. Reddish-brown, tubular concretions of iron, called *pipestems,* also are found. These cylindrical features, oriented vertically in loess exposures, formed around plant roots that once penetrated the loess. Abundant fossil mollusks also are present, most commonly the delicate shells of terrestrial snails that lived on the land surface during the period of loess deposition.

The tendency of loess to stand in vertical faces and the natural vertical partings that often exist near the margins of an exposure pose an environmental hazard in this landform region during particularly wet periods. Water penetrating the loess lubricates these natural zones of weakness, and collapse can result in serious landslides, as the loess sloughs off steep sideslopes. Fresh scars on the landscape where this shearing took place are prominent after heavy rains, and road maintenance crews sometimes must be called to reopen roads clogged with dislodged loess. Gully erosion also is a severe and persistent problem to soil conservationists working in the loess hills region. The amount of eroded sediment carried in the streams draining this area is among the highest recorded in the United States.

Though the western boundary of this region has a very sharp topographic expression and is easily distinguished in the field, the eastern border is difficult to define. The rough terrain gradually tapers off, as does the loess thickness, and merges with the rolling landscape of the Southern Iowa Drift Plain. The more subdued slopes in the eastern part of the region are farmed. However, in the areas of greatest relief, only the valley flats can be cultivated. The rougher terrain is left to the growth of natural vegetative cover, which often is used as permanent pasture. Locally, in this high-relief area, vegetation is very sensitive to sun exposure, wind, and moisture conditions, and forms a unique ecological niche of special interest to botanists. Grasses dominate on the ridges and exposed sideslopes, with occasional clumps of drought-resistant plants such as the yucca, reflecting a nearly desert-like environment. Shrubs and trees are found in the valleys and on the lower, protected slopes.

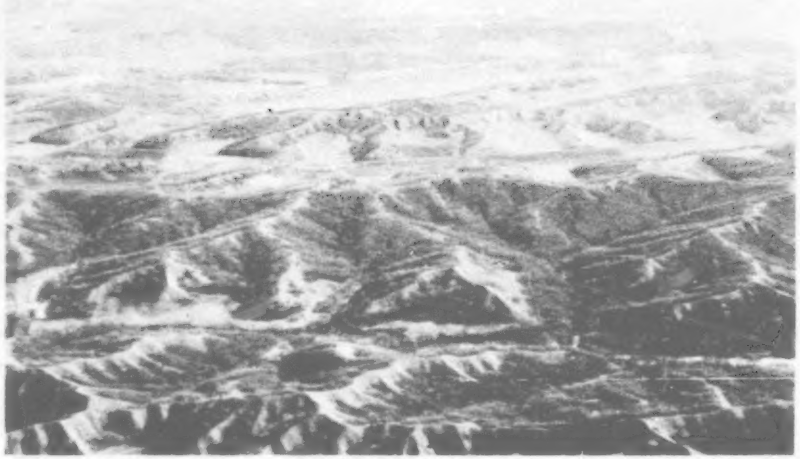


Figure 37. Aerial view of Preparation Canyon State Park in the Western Loess Hills, Monona County.

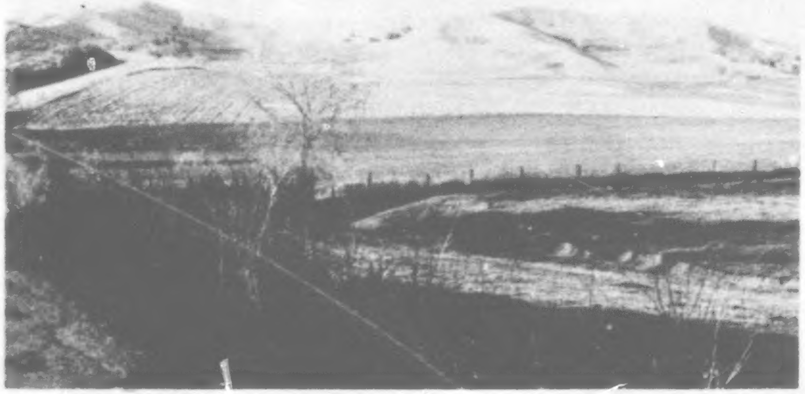


Figure 38. Western Loess Hills between Turin and Soldier in Monona County.

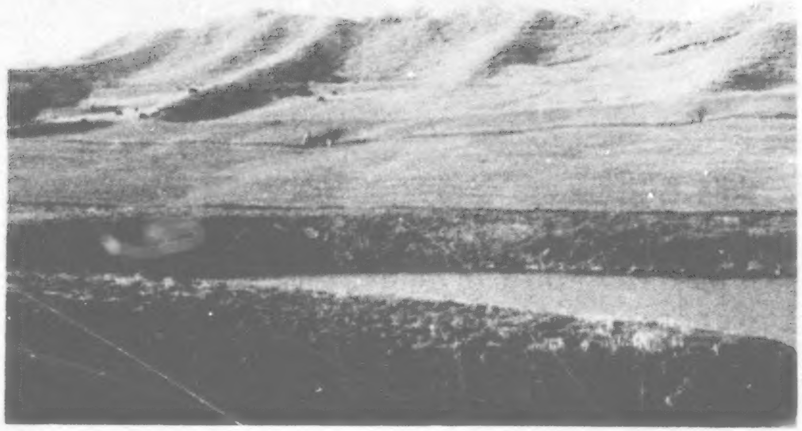


Figure 39. Cattle grazing on loess hills north of Turin, Monona County.

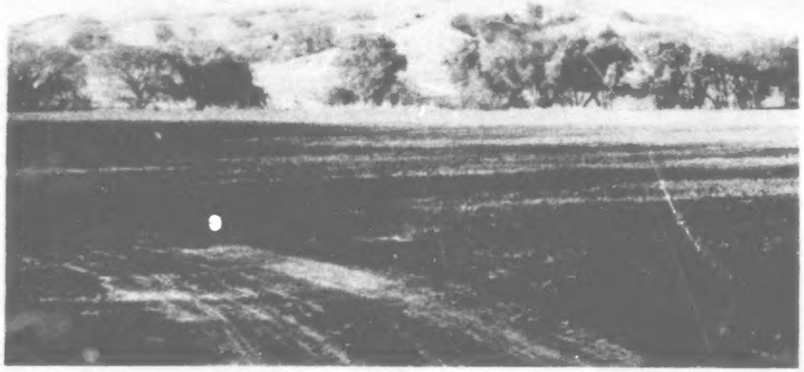
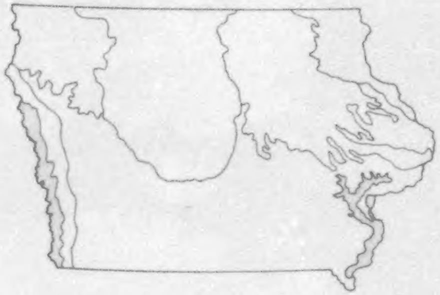
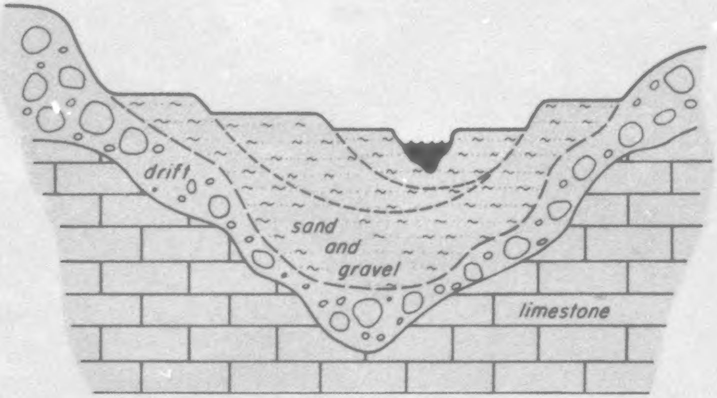


Figure 40. Western Loess Hills north of Turin, Monona County.



ALLUVIAL PLAINS



> *". . . standing on its grassy summit one looks out upon a marvelous picture. The broad valley of the Mississippi lies spread out beneath, bordered by its picturesque bluffs. The luxuriant vegetation of the river is a vivid green, with darker stripes of the same color formed by the fringes of timber along the edges of the water channels. Threads of blue intersect the level plain in a network of water courses which in places widen out into broad lakes and lagoons. Variety is added to the scene by an occasional river steamer pushing before it a huge lumber raft, or a scow heavily loaded with clam shells for the button factories farther down the river."*
>
> —A. G. Leonard
> *Geology of Clayton County* (Iowa) 1906

Iowa has many small streams and creeks that can be crossed with a good long-jump or by the careful alternation of feet on conveniently lodged stepping stones. It is time well spent to look closely at what is going on within these stream channels, for in this micro-environment we get a close look at the single most important geologic activity to modify Iowa's landscape since the Pleistocene glaciers wasted away (fig. 41). Geologically speaking, stream erosion is "where the action is," at the present time. Grain by grain, sand is moved downstream, rolling or bouncing along the streambed, swept quickly through the narrow deeper areas scoured clean by more rapid currents and then perhaps lodged temporarily at the downstream end of a broad rippled shoal of other sand grains. The outer curves of winding stream channels gradually cut away at the stream banks, adding more sediment to the stream. What the stream cannot carry often accumulates as *point-bar* deposits on the inside curves of bends farther downstream. More water and stronger currents will move greater amounts of larger-diameter material downstream. Less water and lower flow velocities will cease the transport of the larger and heavier sediments in favor of fine particles.

This process, easily observed but seldom appreciated for its geologic significance, is at work now as it has been for millions of years of earth history. Geologists find ancient channels of sandstone within Iowa's sedimentary rock layers—evidence of river courses through landscapes never seen, flowing to oceans of which only

Figure 41. Catfish Creek in Dubuque County is a good example of the numerous small streams presently modifying the Iowa landscape.

fossils and rock remain. We noted earlier that Iowa's glacial deposits buried a landscape of hills and valleys which are still present in the bedrock surface though hidden now from our view. Many of these buried valleys contain sand and gravel deposits that now are sought by well drillers as excellent sources of water. During the thousands of years since glacial ice melted from Iowa, stream erosion and deposition have been active, from the smallest of creeks to the giants among the world's rivers (fig. 42), reducing the upland elevations and filling in the basin lowlands. Alluvial plains are those distinctive pathway landscapes where this process is presently at work.

With the exception of the Des Moines Lobe in north-central Iowa, the state's land surface is well drained by numerous rivers and streams. These natural waterways always leave distinctive imprints on the landscape in the form of valleys, floodplains and terraces. The size and complexity of these landscape features will vary with the length of time the stream has existed, the volume of water it carries, and the type of earth materials through which it flows. In Iowa, topographic features resulting from alluvial or stream processes are found along the Mississippi and Missouri River valleys (fig. 22), at the state's eastern and western borders, as well as along many of the state's interior stream valleys. The distribution of major rivers in Iowa is shown in figure 23, as well as the drainage divide that separates the watershed of the Mississippi River from that of the Missouri. The patterns of dissection these rivers impose on the state's land surface are illustrated vividly on the Relief Map of Iowa (fig. 26). In addition, the lowest point in Iowa is on the alluvial plain where the Mississippi and Des Moines Rivers join in Lee County (figs. 23, 24). The elevation here (SE ¼, sec. 34, T. 65 N., R. 5 W.) is 480 feet above sea level.

Floodplains, as the name implies, are the low-lying level land areas adjacent to a river channel. These plains are flooded when the river is carrying an excess volume of water, as often occurs in the spring of the year. They are characterized by relatively flat surfaces and poorly drained areas that contain marshes, backwater sloughs, and

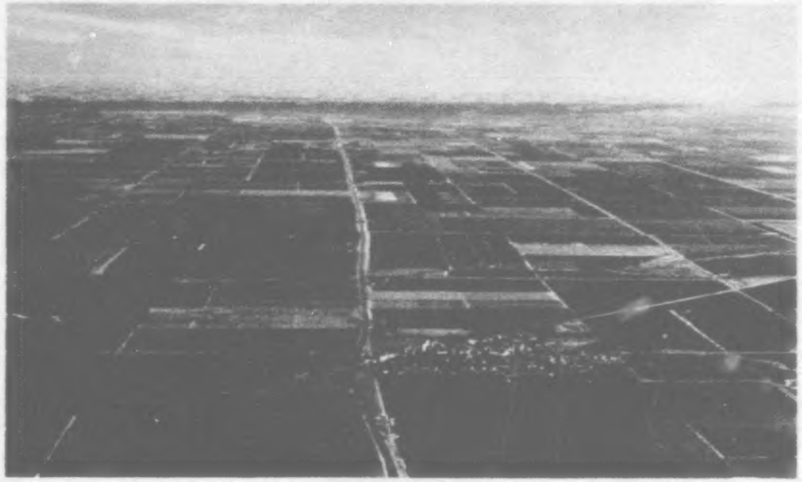


Figure 42. The wide Missouri Valley at Hornick in Woodbury County. This view is to the west, across the checkered farm fields to the snow-covered bluffs on the Nebraska side of the valley.

occasional stands of timber. Floodplains are usually scarred with ridges and swales that mark earlier *meanders* or migrations of the river channel. Isolated, crescent-shaped bodies of water known as *oxbow lakes* sometimes remain in these abandoned segments of river channel (fig. 43). This particular environment, while present along many Iowa streams, is developed on a majestic scale within the Missouri and Mississippi Valleys. The sinuous association of land and water throughout the lengths of these alluvial valleys contribute to their important role as natural flyways, hosting hundreds of thousands of migratory waterfowl each spring and fall.

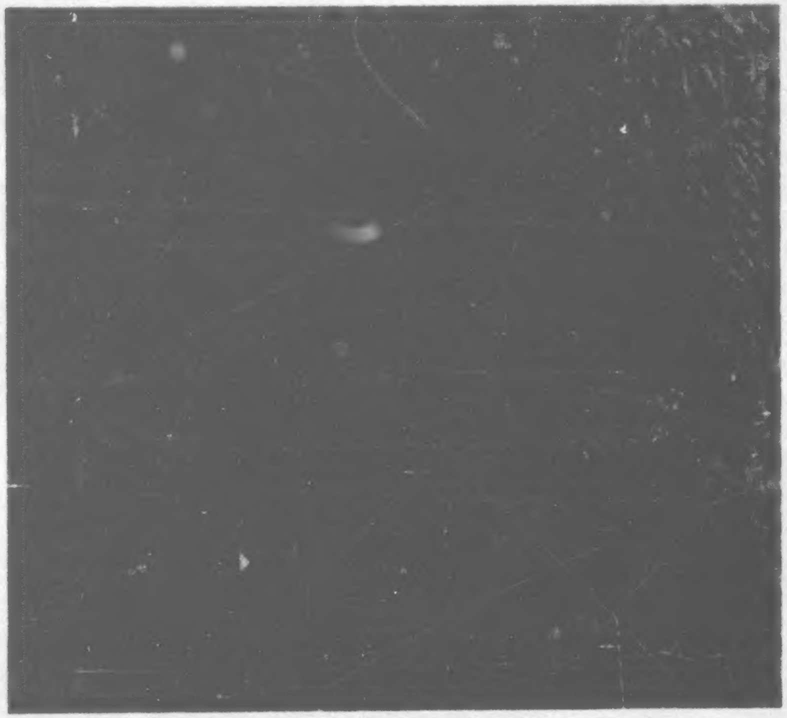


Figure 43. This 1973 NASA, color photograph was taken at an altitude of 60,000 feet over the Missouri River valley. Shown are the towns of Loveland, Missouri Valley, Modale and Mondamin. Interstates 80 and 29 are prominent. Note the large oxbow lake (DeSoto Bend) and the numerous meander scars of earlier river channel migrations across the floodplain. Note differences in landuse between the alluvial plains and the bordering loess hills.

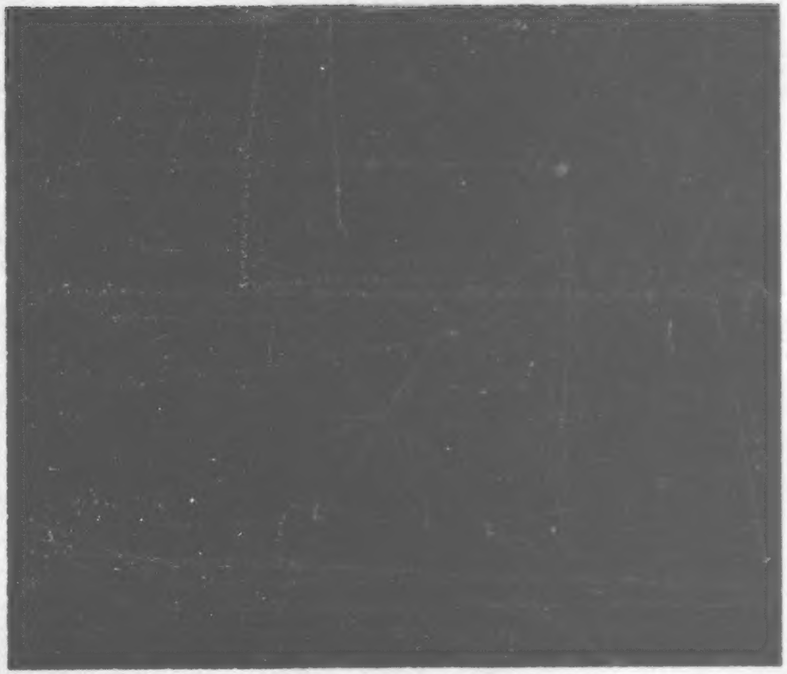


Figure 44. This color-infrared photograph of southeast Iowa was taken by SKYLAB II astronauts in 1973 at an altitude 270 miles above the land surface. The alluvial plains of the Mississippi, Wapsipinicon, Cedar, Iowa and Skunk rivers are clearly shown. The Lake Calvin Basin, just left of center, is outlined by the converging Iowa and Cedar rivers.

We know that river channels do not remain stationary in their valleys. We can observe their horizontal wanderings from the meander loops and oxbow lakes of the floodplain surface. Nor do river channels maintain their vertical positions within their valleys. Evidence for these changes within a valley are recorded in terraces, another commonly observed element of the alluvial plains landscape. These higher, but also level, land surfaces stand above the present floodplain and are remnants of former floodplains, abandoned when the stream began a new phase of downcutting. Terraces, like floodplains, are usually composed of materials transported by water, and therefore contain stratified or layered deposits of clay, sand, silt, and gravel. Many older terraces also are mantled with loess. These unconsolidated deposits generally are very porous and allow easy horizontal and vertical movement of water through their sediments.

A secondary topographic form associated with alluvial plains are sand dunes. Fine sand often is exposed on the floodplain surface or in sand bars within the stream channel. If not securely anchored with plant cover, this sand easily can be blown by the wind to higher elevations. Accumulations of dune sand may be present along terrace margins or be found fringing the leeward sides of the valley.

Included in this category of alluvial plains is one area in eastern Iowa known as Lake Calvin. This prominent feature of the landscape is an extensive level lowland which contrasts sharply with the surrounding rolling uplands. The Lake Calvin Basin is roughly V-shaped in plan view as it extends along the Iowa and Cedar Rivers upstream of their confluence at Columbus Junction (fig. 44). The area is characterized by clearly defined valley walls, broad floodplains and terraces, and sand dunes (figs. 45, 46, 47). Wells drilled throughout the basin show that the upper portion is underlain by a thick accumulation of water-sorted and stratified sediments.

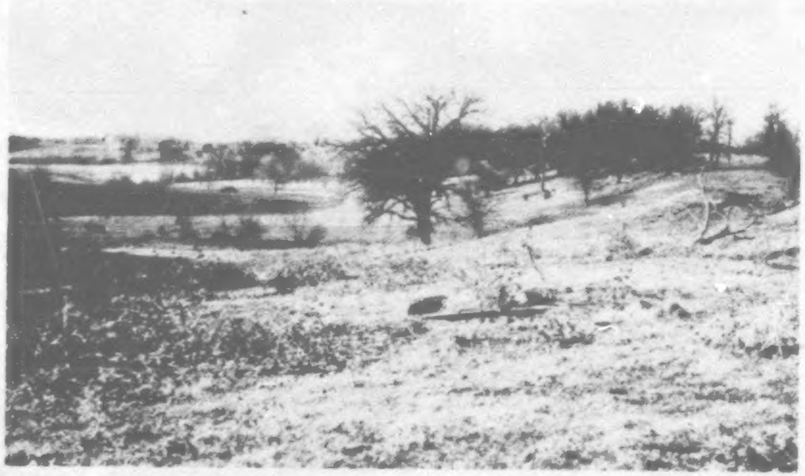


Figure 45. Terrace features are characteristic of the Lake Calvin Basin. Here, in southern Johnson County, a distinct slope marks the break between the terrace surface (right and background) and the lower, present floodplain of the Iowa River (left).

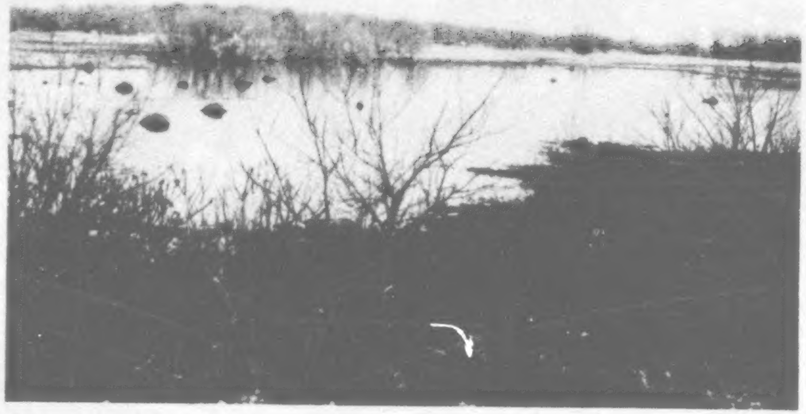


Figure 46. Abandoned meander channels on the Iowa River floodplain within the Lake Calvin Basin are used as wildlife conservation areas. Muskrat dwellings dot the water in this part of Cone Marsh in Louisa County.

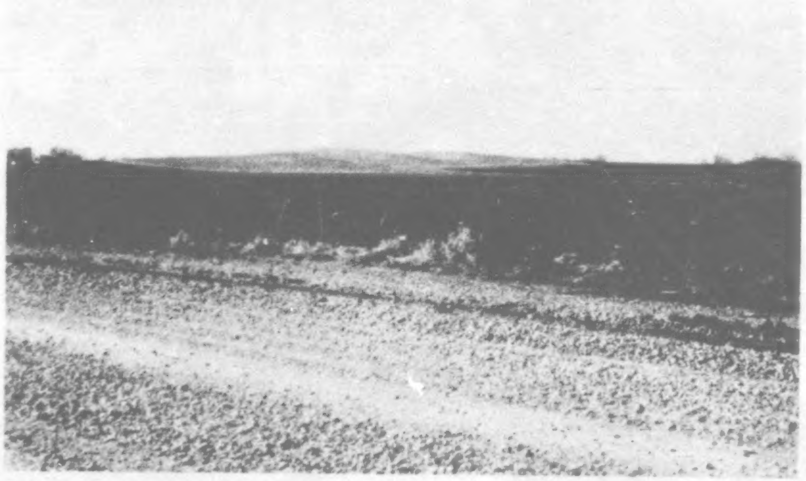


Figure 47. A sand dune on the "intermediate" terrace within the Lake Calvin Basin is seen in relief against the skyline. Note the sandy area has not been plowed.

For many years geologists believed Lake Calvin was the site of a large Pleistocene lake, formed when the Illinoian ice sheet crossed the Mississippi and penetrated into eastern Iowa, ponding drainage of the Iowa, Cedar and Wapsipinicon Rivers. However, recent field evidence indicates that terrace sediments within the basin are Wisconsinan rather than Illinoian in age. More drilling and detailed study are needed to determine the nature of basin development through the Pleistocene, that is, whether it was truly a lacustrine, or lake feature, or rather the result of a complex series of alluvial events.

Alluvial plains often are abrupt and comparatively narrow, elongate landscapes. As such, they exhibit interesting patterns of human activity. Human travel and settlement in both prehistoric and historic times took place along river valleys. Artifacts, mounds, fire pits and other evidence of Indian habitation commonly are found along the bordering bluffs and on the terrace margins of large alluvial valleys. The stream valleys were wooded, in contrast to the open grasslands of the upland prairies; they offered shelter, fuel, water and a supply of fish and game to Iowa's earliest habitants. Nearly all of the state's principal cities grew from settlements located along major river valleys. The known hazards to human occupation from naturally occurring floods indicate that modern usage of floodplains should be reserved for agriculture, recreation, woodland, wildlife, pasture, and economic mineral resource operations. The higher and better-drained terraces are more suitable for permanent urban structures and transportation facilities. The unconsolidated deposits of sand and gravel that underlie floodplains and terraces are an important natural resource, both for road construction and maintenance materials, and for dependable sources of shallow ground-water supplies.

With the perspective of geologic time in our minds as we examine Iowa landforms, we know that alluvial plains are among the most "recent" of the state's landforms. Where river channels meander and floodplains flood with historical regularity, we see the most contemporaneous features of a geological nature that we can observe among the state's landforms. However, the valleys that confine these alluvial plains may vary considerably in their ages. The cutting of some valleys of the Paleozoic Plateau may date from pre-glacial time and their terraced sediment fillings record the fluctuations of past glacial periods. On the other hand, many valleys of the Des Moines Lobe, as we shall see, have barely started to excavate a place for themselves in the landscape.

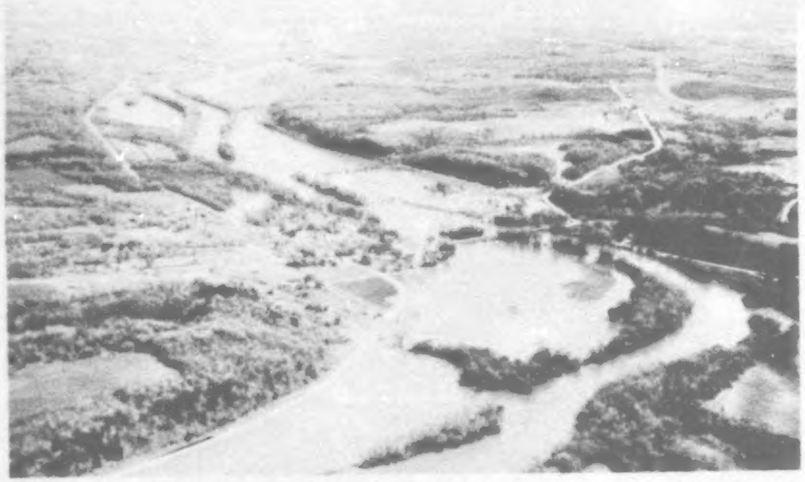


Figure 48. Floodwaters of the Skunk River have escaped the tree-lined river channel and covered the adjoining floodplain at Augusta in Des Moines County.

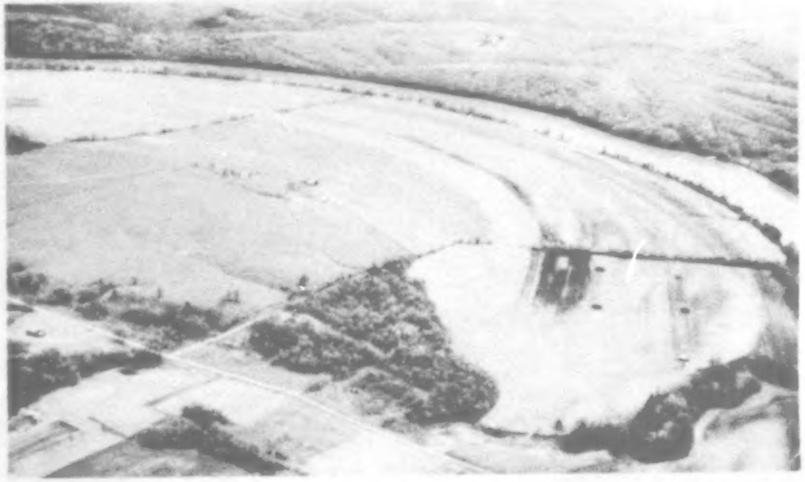
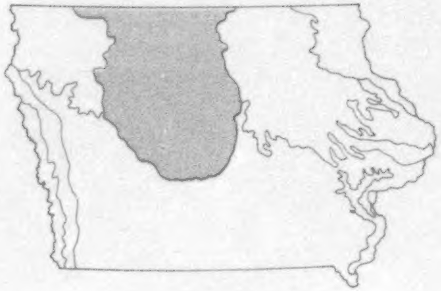
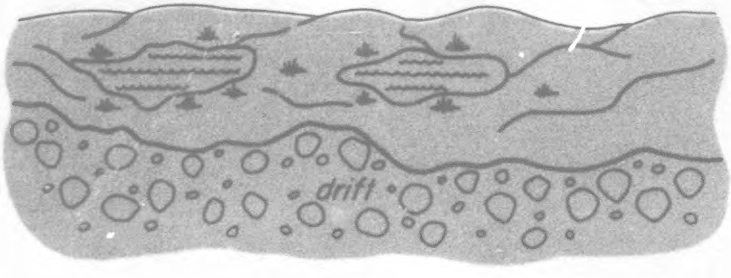


Figure 49. Large point-bar deposit developed by accretion on the inside curve of a migrating bend in the Des Moines River, Van Buren County.



DES MOINES LOBE



"We have plains wide extended, so level that for the passing traveler no inequality can be perceived; towns may hail towns across the unbroken fields and houses dot the distant landscapes like blocks upon a sheet of cardboard. We have precipitous hills rising like miniature mountains directly out of the plain, some of them in groups two or three hundred feet high enclosing lakes, like mountain lakes far above the general level, mantled in native forest and looming blue along the prairie horizon visible for miles and miles; we have townships of alternating marshes and knobby hills without any natural drainage whatever, and we have valleys with gently flowing streams bordered by softly rounded, sloping hillsides perfectly adapted to every phase of agricultural effort."

—Thomas H. Macbride
Geology of Kossuth, Hancock, and Winnebago Counties (Iowa) 1903

Most of the state's landform regions reflect both an association with the periodic presence of Pleistocene ice sheets, and later landscape modification: the stream-dissected plains of glacial till in southern Iowa, the intricate wind-deposited accumulations of loess in western Iowa, and the state's river valley floodplains and terraces composed of sediments released by glacial meltwater. However, the Des Moines Lobe of north-central Iowa provides the only view in the state of landscapes actually shaped by the ice of the Pleistocene glaciers, with little modification since then.

The final thrust of the continental ice sheets over large areas of North America took place during the Wisconsinan division of Pleistocene time. The southern margins of this ice sheet were quite irregular, and one particularly active lobe of ice pushed "briefly" into north-central Iowa. Radiocarbon dating of organic material associated with the deposits of glacial till indicates that this last intrusion of glacial ice entered the state about 14,000 years B.P. (Before Present) and was nearly gone 1,000 years later, or by 13,000 years B.P. The shape of this particular landform region corresponds to the lobate

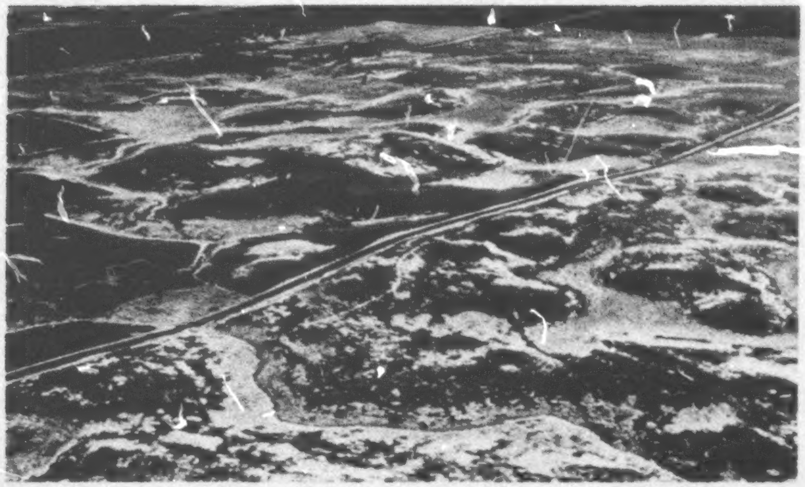


Figure 50. Hummocks and depressions, accentuated by snow cover, characterize knob and kettle topography on the Altamont Moraine near Superior in Dickinson County. Note relationship to plowed fields.

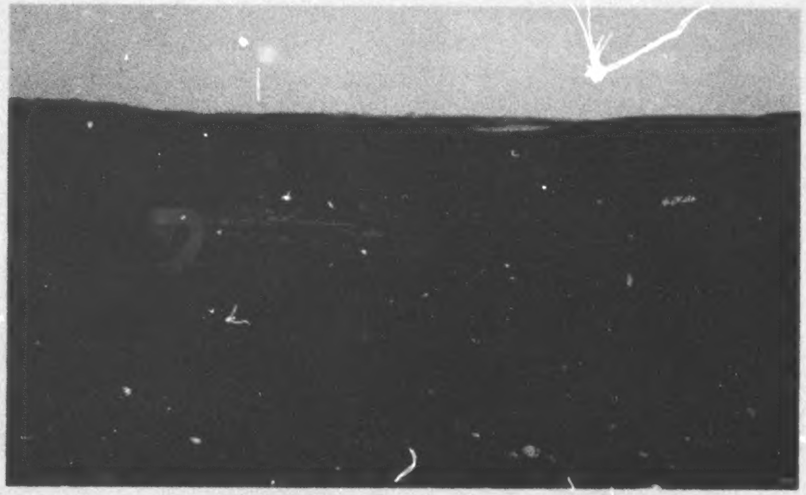


Figure 51. Big Kettle is an enclosed depression within the knobby terrain of the Altamont Moraine west of Milford, Dickinson County. This is an excellent example of landforms developed from stagnant glacial ice. Note the boulder-strewn surface of glacial drift and the ponded drainage.

form of this extension of Late Wisconsinan ice into Iowa (fig. 22). The capital city of Des Moines is in the vicinity of the southern terminus of the ice lobe, and lends its name to this distinctive landform region (fig. 8).

The radiocarbon-dating method is effective in clocking glacial events during the Late Wisconsinan span of geologic time. Abundant plant and animal remains found at various depths throughout the area once covered by the ice sheet enable researchers to unravel more about the details of this glacial intrusion into the Upper Midwest than about any previous stage of ice advance. Extensions of the continental ice margin, of which the Des Moines Lobe is an example, can be documented in time, and corresponding deposits of glacial till can be distinguished. Geologists speaking of subdivisions of the Wisconsinan apply the term Woodfordian or Cary to identify the particular age of the glacial drift within the Des Moines Lobe of Iowa.

Variability best describes the appearance of the land within this region. It does not possess the more predictable uniformity of rolling hills, homogeneous sediments or level plains of other regions. Much of the land is flat to slightly irregular, but bands of rough, knobby terrain appear abruptly and are gone again within a few miles or less (fig. 50). Numerous ponds and marshes cluster in low areas between knobs and have no drainage outlets. Small streams in the more level areas are shallow and sluggish, seemingly without purpose or direction. The few larger rivers that do drain this region and its borders have excavated deep valleys on whose sides remain extensive terraces of sand and gravel. In fact, some valleys appear excessively large for the size stream they now contain, indicating they carried greater volumes of water and sediment in their past than at present. Natural lakes dot the Des Moines Lobe, and numerous bogs, swales and circular depressions indicate the sites of previously ponded water (fig. 51). Soils often are poorly drained and dark-colored, containing large amounts of organic material. Soil landscapes may appear strongly mottled, resulting from variations in texture, slope and natural drainage. Cobbles and boulders of igneous and metamorphic origin are seen scattered over the landscape without regard to topographic position. These surface erratics are components of glacial till, which, except for layered alluvium in the river valleys, underlies nearly the entire region, hill and flat alike.

The rumpled appearance of the surface, the ponded water, the unsorted materials beneath the landscape, and the presence of large rocks and boulders foreign to Iowa are tell-tale signs of glacial occupation. The Des Moines Lobe is constructed of glacial drift plucked by the expanding ice from lands to the north and strewn over north-central Iowa into seemingly irregular and disconnected landscape features. However, a look at this region from above reveals a pattern to the landscape not seen from ground level. The irregularly spaced hills and swales, often described as *knob and kettle topography,* actually form large arcuate bands which parallel the lobed outline of this landform region. Their alignment, as shown in figure 22, indicates their origins were closely associated with the changing margins of the Wisconsinan ice lobe. *End moraine* is the term applied to these hummocks and ridges of glacial drift. Four aligned end-moraine systems can be mapped on the Des Moines Lobe. The Bemis is the southernmost of these moraine systems, and it marks the presently defined maximum advance, or *terminal* position, of glacial ice into Iowa during Wisconsinan time. As the melting and wasting of the ice progressed to more northerly positions, successive *recessional moraine* systems were left behind—the Altamont, Humboldt and Algona.

The relief on these morainal bands varies from the well-developed hills of knob and kettle terrain to quite level land, where minor moraine crests, sometimes called washboard topography, often are barely perceptible to the eye. Ocheyedan Mound in Osceola County, for many years considered to be the highest point in Iowa, and Pilot Knob in Hancock County are prominent examples of the hills associated with these morainal belts (fig. 52). Between the bands of end moraine, where the ice wasted at a more uniform rate, the land surface is characterized by only slight irregularities. These are areas of *ground moraine,* and they, too, are underlain by ice-transported materials. However, there are no distinct parallel patterns of topographic development as seen in the linear ridges of end moraine.

So far, only the larger rivers have had time to establish clearly defined valleys. In fact, these valleys are the only large-scale erosional features on the Des Moines Lobe, which is essentially a constructional or depositional type of terrain. They developed from meltwater channels where glacial debris was carried away, sorted and

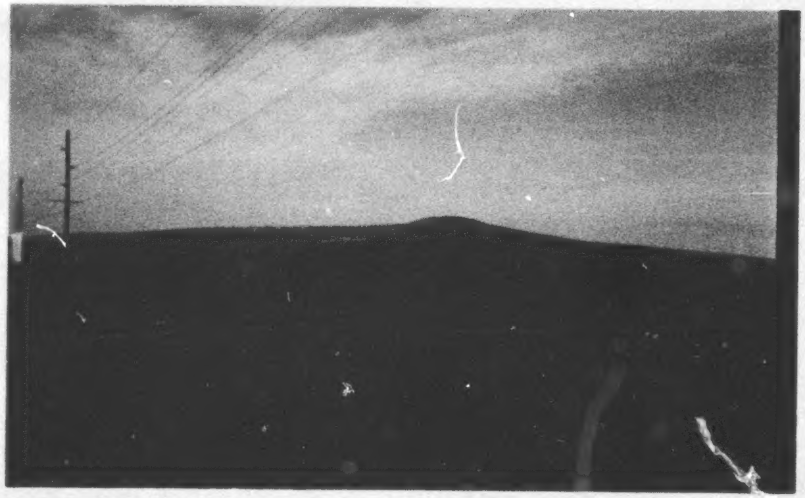


Figure 52. Ocheyedan Mound is a prominent knob of Wisconsinan glacial drift on the Bemis Moraine in Osceola County.

Figure 53. Spirit Lake is one of the larger natural lakes that characterize the glaciated terrain of the Des Moines Lobe. Note the glacial erratics along the shoreline.

deposited downstream as *outwash*. Some of these deposits are now the sites of commercial and gravel production, both on and off the Des Moines Lobe.

Nearly all of Iowa's natural lakes are contained within the Des Moines Lobe (fig. 23), and they become particularly prominent among the morainal hills northward toward the Minnesota border. Lake Okoboji, Spirit Lake, Clear Lake and the numerous smaller ponds and sloughs are characteristic of the "young" post-glacial landscapes and their relatively undeveloped drainage networks (fig. 53). The Iowa "Great Lakes" are a popular vacationing area and, along with the ponds and marshes sometimes referred to as prairie potholes, provide important wildlife habitats. However, poor surface drainage also is a serious impediment to soil productivity, and many of the region's natural wetlands were drained as agriculture became more important to the area.

In summary, the uniqueness of this landform region results from its geologically recent encounter with ice sheets from the North. Because this last appearance of glaciers in Iowa took place during and after the period of greatest Wisconsinan loess deposition in the state, the Des Moines Lobe lacks an obscuring mantle of loess. The result is an exceptionally clear picture of the land surface nearly as the ice left it. In the 11,000 or 12,000 years that have passed since the ice melted, weathering and erosion have made some progress in modification of the landscape. Slope angles have changed and earth materials from hill summits have started the descent to lowland positions. Even though some of the initial relief has been reduced, the topography and landforms of the Des Moines Lobe remain characteristic of terrain recently occupied by glacial ice.

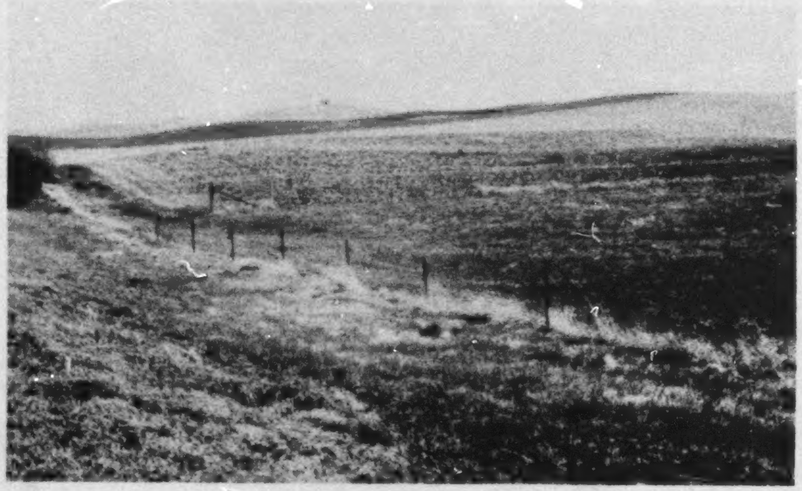


Figure 54. Rough terrain of the Des Moines Lobe end-moraine systems reflect accumulations of glacial drift along the ice margins during periodic pauses in melting.

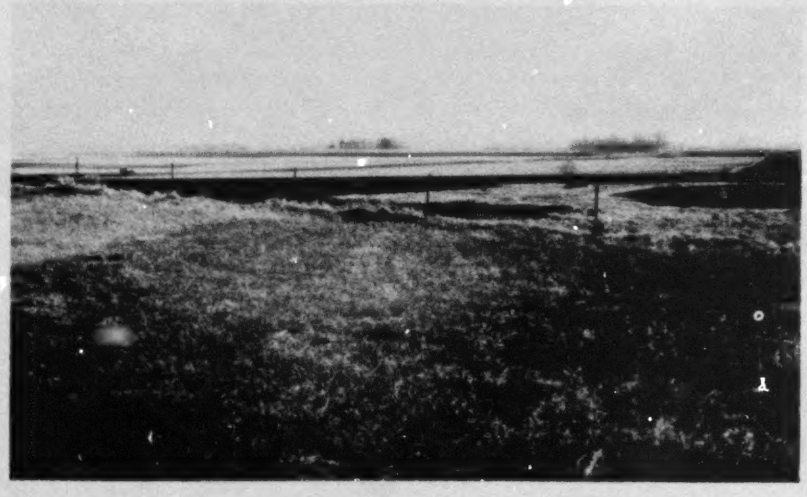
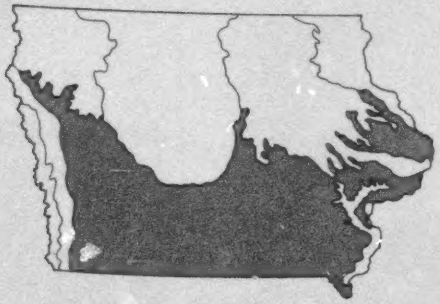
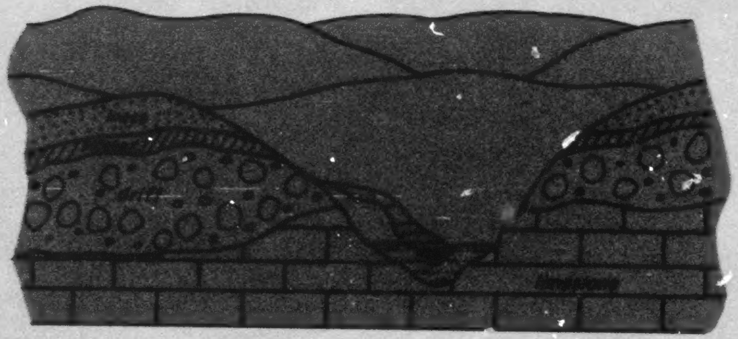


Figure 55. Many areas of the Des Moines Lobe are nearly flat. These stretches of level terrain are characteristic of ground moraine where glacial ice wasted at a uniform rate.



SOUTHERN IOWA DRIFT PLAIN



> *"The result is that the original upland plain has been cut by a series of long relatively narrow river valleys with high narrow ridges between. The resulting topography was quite fittingly described by the early settlers who spoke of the region as the "devil's washboard." An east-west traveler must cross a series of alternating ridges and valleys. The north-south traveler may usually find a ridge road. From the latter, looking off over the country, the tops of the successive flat-topped ridges appear rising to an even surface and restoring the old plain in which the valleys have been carved."*
>
> —H. Foster Bain
> *Geology of Decatur County* (Iowa) 1898

The topography of the Southern Iowa Drift Plain is perhaps most representative of "typical" Iowa landscapes. It is certainly the largest of Iowa's landform regions, and for many people traveling our east-west interstate highway, it is the only landform region of which they will get a good view (figs. 22, 24). The topography of this area is best described as one of steeply rolling hills interspersed with areas of uniformly level upland divides and level alluvial lowlands. In many places, this rolling plain presents an illusion of long heavy ground swells on an open ocean. Individual hillslopes often display a texture of finely etched rills or drainageways which give a distinct ribbed or furrowed appearance to the terrain (fig. 56). The largest percentage of the land surface is sloping, with smaller areas being level, either as upland flats or as stream bottomlands.

It is interesting to observe the gradual shifts in these relationships from the eastern part of the region to the western part. Much of the terrain in southeastern Iowa consists of flat, table-like uplands with steep hilly land occurring only near the margins of stream valleys. The amount of level bottomland along streams is small by comparison with the extensive areas of upland. Traveling westward, the terrain becomes more dissected, with upland divides present but smaller in area, and most of the land surface is in hillslope. The terrain continues to change subtly toward southwest Iowa where the upland levels disappear almost entirely and the hills seem aligned as crests of great

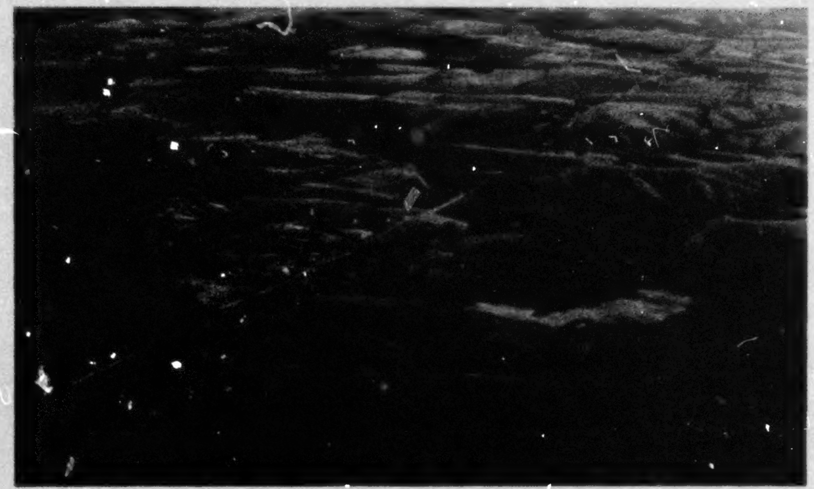


Figure 56. The glacial drift in Madison County near Pammel State Park, southwest of Winterset, is dissected by numerous drainageways that give a distinct ribbed appearance to the terrain. Farm impoundments are common throughout this steeply rolling region.

waves with broad troughs between them. Here the most extensive areas of flat terrain occur in the river valleys. Though the relative amounts of *tabular* uplands, rolling hills, and valley lowlands vary throughout the region, the arrangement of these landscape features and their associated relief are unifying characteristics of the Southern Iowa Drift Plain.

There is a feeling of enclosure when among the hills of this dissected and rolling region. One's view extends only as far as the next rise or the next bend in the road. There are no open, long-distance vistas except those from hillcrests which return repeatedly to the same elevation and provide a view over the billowy landscape beyond. This characteristic provides an identifiable contrast with the Iowan Surface which, as we will see in the next regional discussion, also is rolling. However, its swells are much gentler and of uneven height, giving the observer more open and unrestricted views of the surrounding countryside.

Throughout this region we see land once covered by massive sheets of glacial ice. However, no clues remain in the shapes of the landforms themselves to implicate their association with the continental glaciers. Features typical of a freshly glaciated landscape have been obliterated by time; there are no moraine systems and no bogs or marshes similar to those observed on the Des Moines Lobe, which are indicative of a youthful landscape where drainage has not yet developed. Instead, the only remaining evidence in this region to verify the passage of the early Pleistocene glaciers is the tens and hundreds of feet of glacial drift carried by the ice and deposited on the bedrock surface.

Throughout most of the region, this drift consists of glacial till belonging to the Kansan stage of glaciation, and below it is an earlier unit of Nebraskan-age till. Except for an intrusion of Illinoian ice into a small area of eastern Iowa (fig. 25), no later ice sheets advanced into this region. Since the close of Kansan time, most of the land has lain exposed to stream erosion, weathering processes, soil development

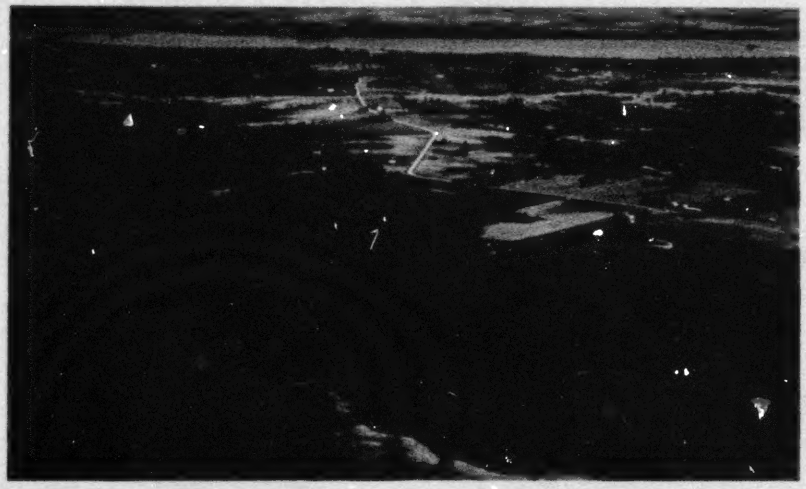


Figure 57. A color-infrared aerial view toward Ft. Madison and the Mississippi River shows the flat-topped upland divides that characterize the eastern portion of the Southern Iowa Drift Plain. Timber grows on the steep slopes where stream dissection is encroaching on the upland flats.

and loess deposition. The result is the efficient *dendritic* drainage patterns that now characterize this region, and which, in turn, account for the land's rolling, dissected appearance and the absence of landforms which reflect their glacial heritage. Only the uniform summits of flat, upland divides and hillcrests described earlier are remnants of the original, once-continuous drift plain (fig. 57).

At the same time this dissected landscape was developing during the latter half of the Pleistocene, loess was deposited over the land surface. The loess mantle is thick enough in some places to provide additional relief and to alter slope angles, particularly on leeward hillslopes and along the borders of stream valleys. The bulk of this loess cover was deposited during Wisconsinan time (Peorian Loess). However, beneath the Wisconsin loess in the western part of the region is an additional wedge of Illinoian-age loess (Loveland Loess). Both loess units are thickest near the Missouri River valley and thin toward the central portion of the region. The Wisconsin loess thickens again near the Mississippi River.

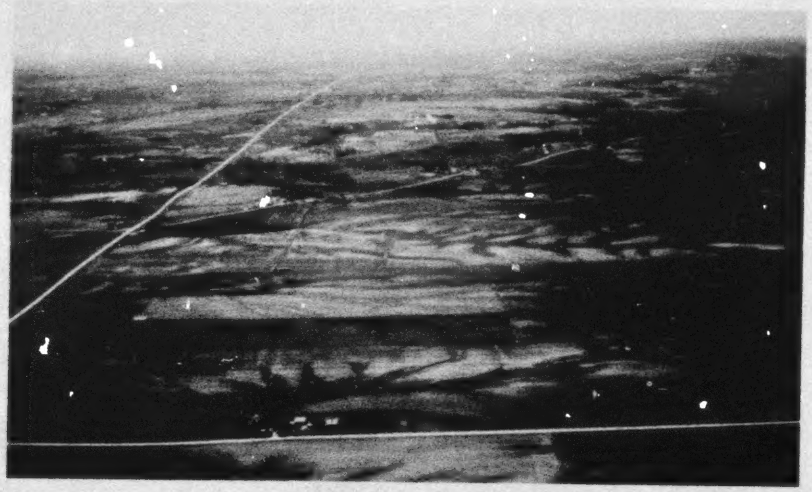


Figure 58. Dendritic drainage patterns are etched by the smallest creeks and rills on the upland surface in Washington County.

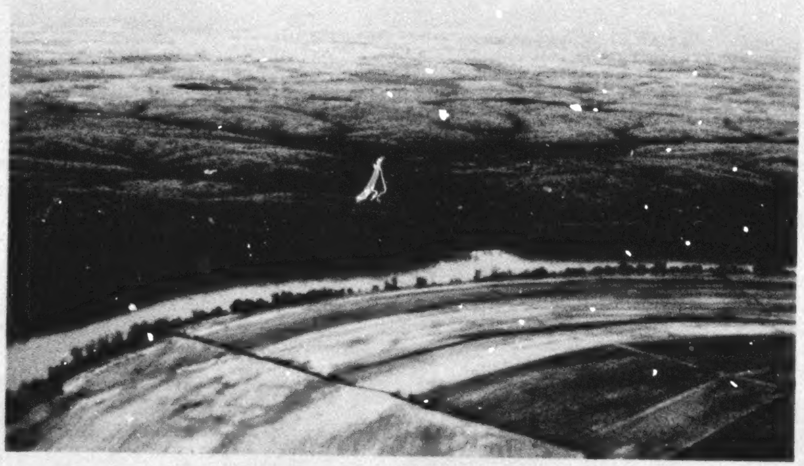


Figure 59. This view of Lacey-Keosauqua State Park shows the dendritic dissection of the uplands in the background. This rough, wooded terrain along the Des Moines River in Van Buren County is characteristic of the deeper valleys eroding through the glacial drift into bedrock.

In the spring and fall when soil color is especially prominent on the hillsides, reddish-brown zones often are noticed. This colorful material, the result of oxidation of contained iron and usually called the *ferretto zone,* is exposed to view where erosion has removed the overlying loess. It is an ancient soil profile, or *paleosol,* that developed on the Kansan till surface during the Late Sangamon interglacial stage. This paleosol, often several feet thick, is a residue composed principally of clay—evidence of long exposure of glacial debris to atmospheric weathering and deep soil development.

In addition to providing a distinctive coloration to some hillslopes in the region, paleosols also have a pronounced effect on local soil moisture and drainage conditions. Because they contain large amounts of clay, paleosols act as effective barriers to the downward movement of water. Rainwater and snowmelt percolating through the loess move laterally when the impervious clay of the paleosol is reached. Seeps or springs commonly develop on hillsides where the clay-rich paleosol is intercepted by the land surface. Here, the paleosol, sometimes referred to as *gumbotil*, usually is thicker, grey-colored and represents soil development during both the Yarmouth and Sangamon stages. Such areas of "gumbo" are notoriously sticky when wet and are well known to farmers working the fields of this landform region.

The rivers of many large valleys throughout the Southern Iowa Drift Plain have eroded completely through the sequence of loess, paleosol and glacial drift into the sedimentary bedrock units beneath. The rough and wooded terrain adjoining these deeper valleys provide scenic recreational areas (fig. 59). The dendritic patterns of stream dissection in this region result in a complex mosaic of cropland, pasture and forest. Contour plowing and grass-backed terraces often are used to help prevent soil erosion from the cultivated hillsides (fig. 60). In addition, this terrain is suitable for the construction of dams for impoundment of streams. Three of Iowa's largest man-made reservoirs are in this region—Coralville, Red Rock and Rathbun. These dams control flooding and also provide recreational opportunities and needed sources of water (fig. 61). Smaller impoundments for individual farm use also are a characteristic feature of landuse in this steeply rolling region. Well water often is not as plentiful here as in other sections of the state. Thus, trapping and storing runoff in farm ponds provides an important water source (fig. 56).

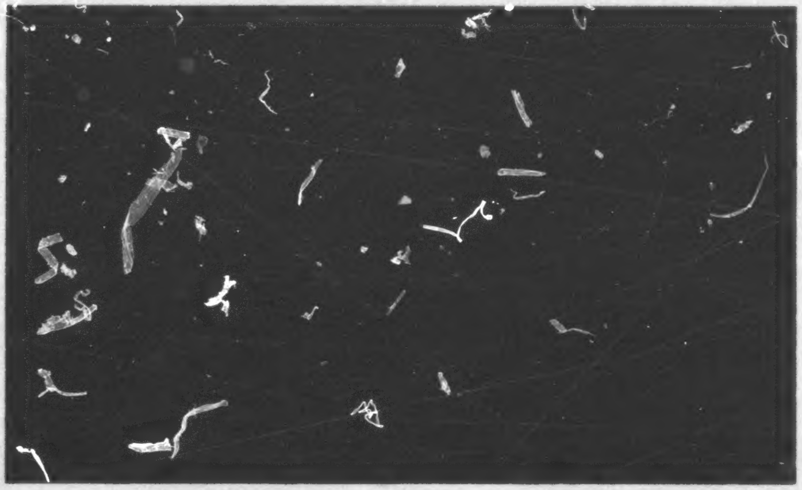
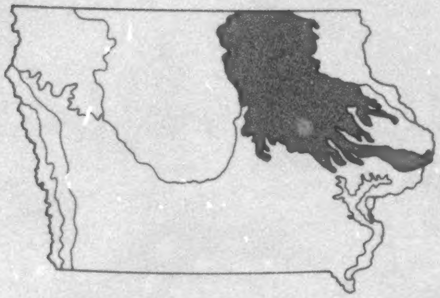


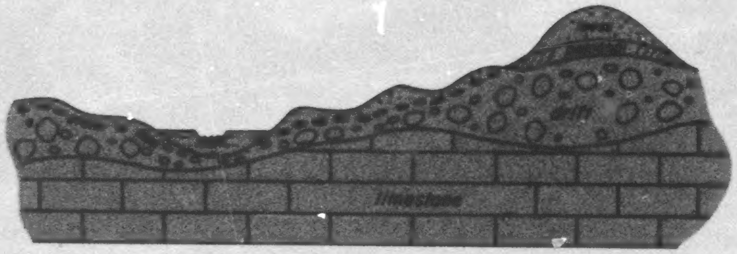
Figure 60. Grass-backed terraces and contour plowing are conservation practices used by farmers to control soil erosion and retain surface runoff. These practices are particularly prevalent in southwestern Iowa, as illustrated in this Pottawattamie County view.

Figure 61. Large impoundments such as the Red Rock Dam and Reservoir on the Des Moines River are contained within the steeply rolling terrain. The many inlets along the shoreline mark the positions of tributary valleys in the well-dissected landscape.

Limestone of suitable quality for road construction and maintenance and agricultural use is quarried, particularly in the eastern half of the area. The Pennsylvanian-age rock formations found in the southwestern two-thirds of the region contain Iowa's coal deposits. These seams of coal frequently are shallow enough for surface mining techniques. Past mining activity left some portions of the land surface scarred with unsightly mounds of acid spoil materials, which are unable to support vegetation and are very susceptible to erosion. There is now a renewed interest in mining Iowa's coal deposits in order to meet the state's increased energy needs. Recent state legislation assured us that reclamation of the mined land to its former, or even improved condition, will be an integral part of any future mining activities in Iowa.



IOWAN SURFACE



> *"Already the boulders that embarrassed the cultivator and to the thrifty eye disfigured the otherwise fair fields to a great extent, have been utilized in building, or have been removed to the boundaries of the farms, where, lying in grim ruggedness, they continue their mute testimony to the reasonableness of the glacial theory and the wonderful activities of nature in the days long gone by."*
>
> —Melvin F. Arey
> *Geology of Black Hawk County* (Iowa) 1906

The appearance of the terrain in most of Iowa's landform regions lends itself without question to well-known and accepted geological explanations. In fact, the state is recognized as an excellent locality for the study of landscape features and deposits associated with ice-age activity during the past one and one-half million years. The Loess Hills, the Alluvial Plains, the Des Moines Lobe, and the Southern Iowa Drift Plain all are fine examples of specific geologic processes at work during different intervals of Pleistocene time. Iowa is even the home of the classic type-localities, the standard field-reference sections recognized by scientists around the world, for those major Pleistocene units referred to as Nebraskan, Aftonian, Kansan and Yarmouth, as well as the Loveland Loess. Such unanimously recognized clarity of geologic form, process and time does not extend to the Iowan Surface. Part of the individuality of this landform region, then, lies in the fact that it is a controversial combination of landforms, materials and geomorphic development, and it long has been a focus of academic attention.

The Iowan Surface is a distinctive topographic region. Its boundaries with the Des Moines Lobe to the west and the Paleozoic Plateau to the east are easily mapped and observed in the field (fig. 22). The southern border is less well defined as it has an irregular outline caused by transecting stream valleys. However, it is clearly a separate topographic unit from the Southern Iowa Drift Plain. On these points most earth scientists are in agreement.

There also is general agreement about the appearance of the landforms within this region. The land surface is level to gently rolling with long slopes, low relief and open views, in contrast to the restricted lines-of-sight within the more billowy landscapes of southern Iowa (fig. 62). The Iowan Surface is sometimes described as having a multi-leveled, uneven, or stepped topography. These levels occur in a gradual progression from the stream valleys toward low crests that mark the drainage divides. It often is difficult to point to a sharply defined valley wall; more often the eye sees only a series of long slopes merging almost imperceptively with the gentle rise to the next interstream divide. Drainage is well established, though stream gradients often are low and a few areas of poor drainage or bog conditions exist. Other features typical of the Iowan Surface as a whole are the scattered areas of large boulders partially buried or lying on the surface. These erratics, composed of rock types not native to Iowa, clearly are of glacial origin, as are those described on the Des Moines Lobe (fig. 63).

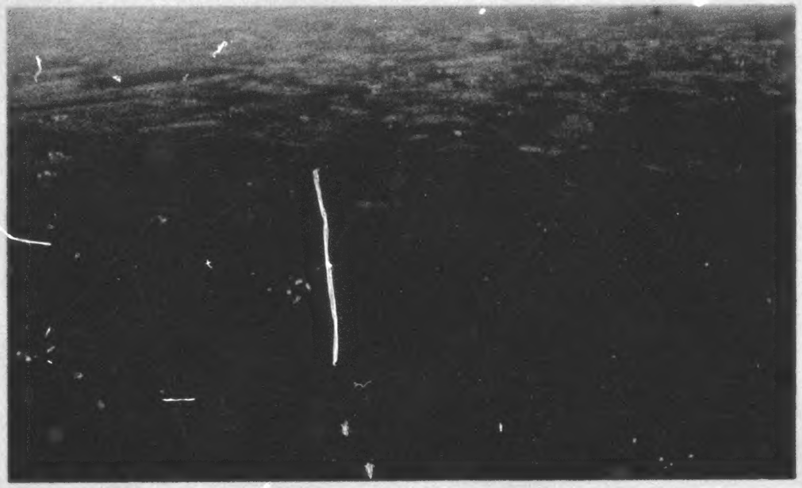


Figure 62. This aerial photograph, aided by a low sun-angle, illustrates the topographic contrast between the gently rolling terrain of the Iowan Surface (left) and the more steeply rolling landscape of the Southern Iowa Drift Plain (right). Near Blairstown in Benton County.

Figure 63. Glacial erratics dot this farm field near Bassett in western Chickasaw County. The long, gentle slopes of the Iowan Surface are seen in the background.

In the southern third of the Iowan Surface, slopes become steeper in the vicinity of the larger river valleys. Prominent elongate ridges and isolated elliptical hills, known as *paha*, are characteristic features of the area (fig. 64). They tend to be concentrated along the lobes of the region's irregular southern border and are oriented in a distinct northwest-southeast direction (fig. 22).

Only a few scattered paha occur in the northern two-thirds of the Iowan Surface. Here, as within the Paleozoic Plateau, karst features have developed where limestone bedrock is close to the land surface. Most noticeable are the sinkholes, or circular depressions, where solution of the underlying limestone by ground water resulted in surface collapse of the thin drift cover (fig. 66).

We have seen in adjacent landform regions to the east and south that high-quality limestone and dolostone are abundant in the eastern half of the state. Quarrying of these rocks is one of the state's more important economic mineral resource activities. Quarries also are common within the Iowan Surface where bedrock is not buried too deeply by glacial materials.

A wide assortment of Pleistocene sediments mantles the near-surface bedrock of this region. Loess is present, but over most of the area it forms only a thin and discontinuous cover. However, the loess, along with blown sand, forms a thick cap on the paha hills and ridges. Glacial till also is distributed over the area, in some places covered by thin loess, at other locations by thin loam or sediments of mixed sizes, and at still other sites no cover is present above the till. Where a cover exists, there usually is a conspicuous concentration of pebbles and cobbles in a narrow zone between the till and its loess or loam cover. This *stone line* or *pebble band* is a commonly observed feature of the Iowan Surface where natural or man-made exposures provide a view of the sequence of Pleistocene materials (fig. 65). However, no stone line is present within the paha. Instead, a well developed paleosol generally is present between the till and its thick loess cap—a sequence recognized as "normal" throughout the Southern Iowa Drift Plain.

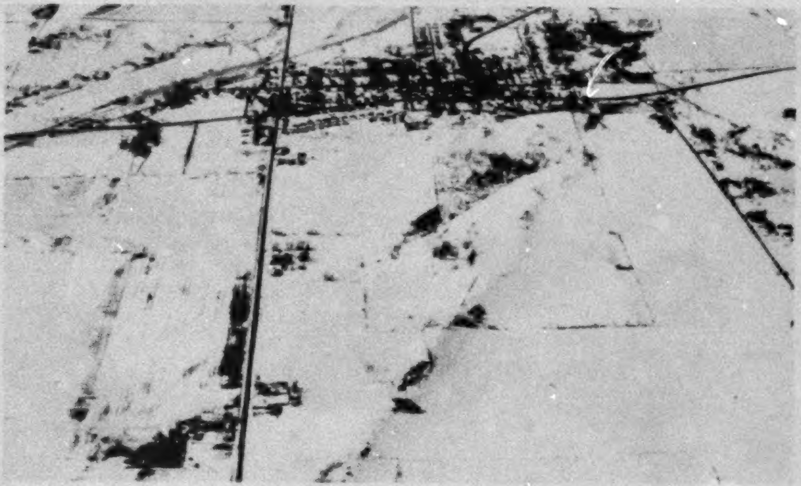


Figure 64. Shadows on the snow cover help identify this elongate, paha ridge just east of Solon in Johnson County. These linear landform features are characteristic of the southern portion of the Iowan Surface.

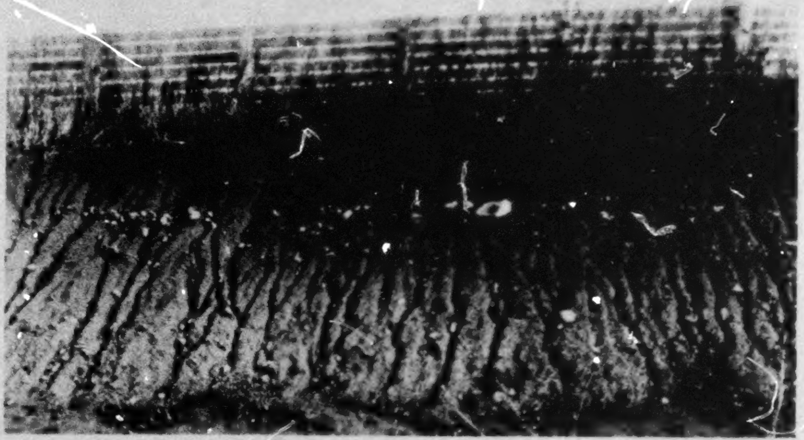


Figure 65. Exposures of the glacial stratigraphy beneath much of the Iowan Surface show thin loess or loam sediments on top of an eroded surface of Kansan till. The contact between the two frequently is marked by a stone line, or lag concentrate of pebbles, as shown here near Denver in Bremer County.

It is this variety of Pleistocene-age sediments and the variations in their vertical and horizontal patterns that sparks such intense interest and inspection by earth scientists and, in turn, has led to a history of divergent explanations for what is seen. These relationships among the Pleistocene materials are not apparent to the casual observer, and the landforms provide few obvious clues to the region's past history. The story must be pieced together by examining the interior of the landscape by core-drilling, and by examining the time dimension with radiocarbon dating. Without discussing the details of geomorphic models and Pleistocene *stratigraphy*, a look at how features of the Iowan Surface have been interpreted is of interest.

In the past, McGee, Calvin, Alden, Kay, Apfel, Leighton and Leverett—names synonomous with the development of Pleistocene geology in the Midwest—offered theories and explanations to account for the development of the Iowan Surface in light of what they saw. The generally accepted view which evolved considered the materials of the Iowan Surface to represent drift deposits of an early Wisconsinan ice lobe that advanced into Iowa prior to the advance of the Des Moines Lobe. The paha were at times regarded as mounds of ice-molded till, and at other times considered to be topographic highs which were by-passed by thin glacial ice.

This picture of the Iowan region as another example of ice-modified terrain, and the general acceptance of the existence of a separate "Iowan drift" was challenged in the 1960's by Ruhe. His field work and published conclusions document convincingly that the Iowan region is a widespread erosion-surface complex, and in no way reflects a surface of glacial deposition. This complex geomorphic feature evolved from normal processes of subaerial erosion, acting on a paleosol-covered landscape of Kansan till, like that present in southern Iowa, *during* the period of Wisconsinan loess deposition. The paha stand along drainage divides, and above the multi-leveled Iowan plain—erosional remnants of a once higher and older land surface. Thus, these paha and interstream ridges are topographic and stratigraphic remnants of the uneroded Kansan till with its paleosol intact, and they are capped by the total thickness of loess available for deposition in this area during Wisconsinan time. The erosion-surface complex advanced in gradual steps from the stream valleys to their bounding interstream divides, and on each developing level, left the stone line or pebble band described earlier—a lag concentrate of coarse pebbles from which the clays, silts, and sands were removed by running water, slope wash and wind deflation. These erosional processes which concentrated the now conspicuous stone line occurred during the time loess was being deposited. Consequently, a full complement of loess could accumulate only on undisturbed topographic highs—the paha and interstream divides.

The last word on the Iowan Surface doubtless will not be heard for some time. It is an intriguing area to which Pleistocene scholars will return again and again to apply and test the principles that now seem evident for explaining the surface and subsurface features of this landform region.

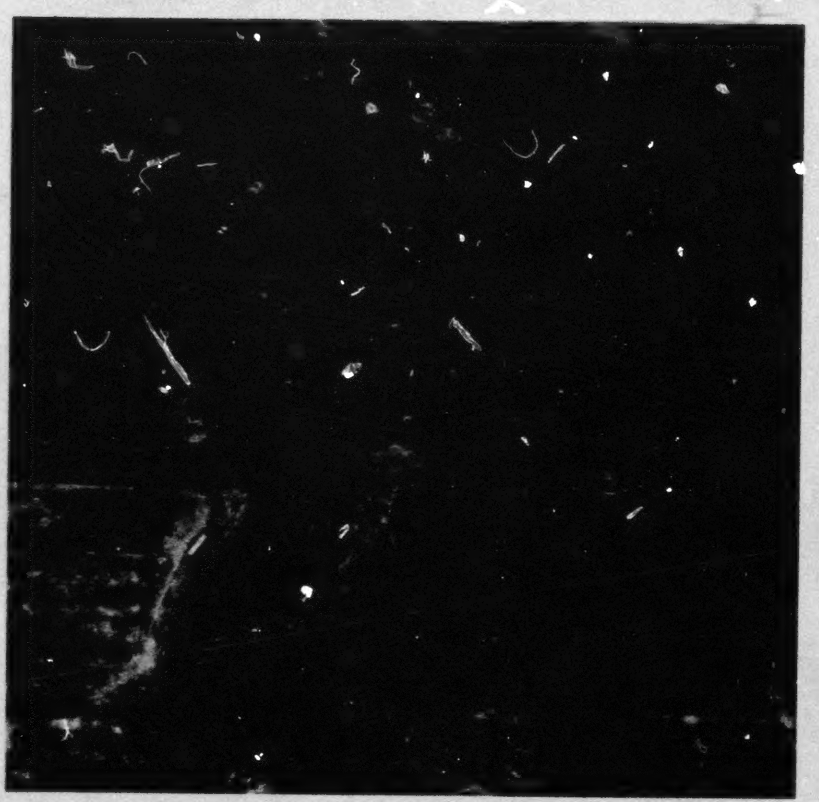
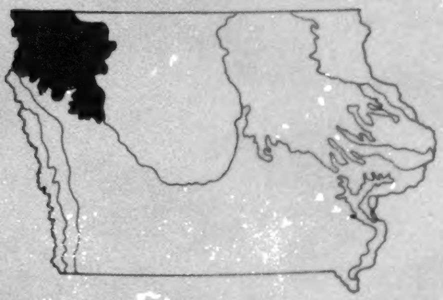
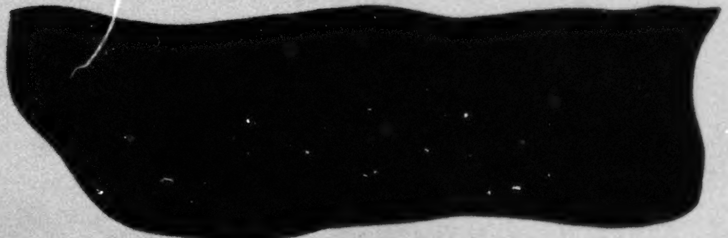


Figure 66. This vertical view of farm fields along Rt. 218 north of Floyd in Floyd County shows numerous circular depressions of sinkholes, characteristic features of karst topography. Solution of underlying limestone resulted in collapse of the land surface. These areas, unusable for crop production, may contain isolated stands of timber, ponded water, or glacial erratics moved out of nearby fields. Photo by Paul G. Allee and Stanley C. Grant.



NORTHWEST IOWA PLAINS



> *"There are no sloughs or lakes . . . and a topographic map of the region would make clear the fact that the entire area is reached by the streams and none left undrained. The minor feeders are not conspicuous enough to be placed on an ordinary map, and only during the rainy seasons do they appear as water courses. The surface of the region, therefore, is decidedly undulatory. . . . There are no sharp ravines with steep sides, but instead there are gradual slopes from a broad crest leading to a broad valley. To gain one crest, however, is simply to discover another hollow. The grades are not steep, they may usually be climbed with a bicycle, and the long even declines make it possible to coast to the bottom of the depression and part way up the next slope."*
>
> —Frank A. Wilder
> *Geology of Lyon and*
> *Sioux Counties*
> (Iowa) 1900

Subtle changes in Iowa's landscape are observed as one approaches the northwestern part of the state. The lowest point in Iowa, along the floodplain where the Des Moines River empties into the Mississippi just south of Keokuk, has an elevation of 480 feet. From this site, elevations in Iowa gradually increase to the north and west (fig. 24). Iowa's highest point is in a farmer's feedlot on a long flat ridge about four miles northeast of Sibley in Osceola County (NE ¼ sec. 29, T. 100 N., R. 41 W). Traverses made by U.S. Geological Survey field crews, working on the 7½′ topographic mapping project in the area, determined this high point to be 1,670 feet above sea level. Ocheyedan Mound, long believed to have the state's highest elevation, was resurveyed on this same project, and though a more noble topographic feature, it is nevertheless only 1,613 feet high. The site of the new high-point is within the Northwest Iowa Plains. Altitudes of this region are uniformly higher than in any other portion of the state. Northwest Iowa is a "jumping-off place," a definite step upward to the High Plains of the Dakotas (fig. 67).

Areas of native woodlands decrease noticeably from eastern Iowa to western Iowa; and in the western part of the state, woodland areas continue to diminish from south to north. The plains of northwest Iowa are markedly barren of trees, except for those clustered windbreaks planted around individual farmsteads.

A corresponding relationship is found in the distribution of precipitation over the state. The highest mean annual precipitation occurs in southeast Iowa with 34 inches per year. Precipitation progressively decreases toward the northwest corner of the state where the mean annual precipitation drops below 25 inches per year. Thus we are looking at a landform region which is higher, drier, and less timbered than any other in the state.

These characteristics are imposed on a gently rolling landscape, very similar in appearance to the low relief of the Iowan Surface (fig. 68). A network of streams is well established over the entire region, and most valleys are broad swales that merge gradually with long, even slopes to the interstream divides. However, the paha and associated paleosols of the Iowan Surface are absent, and with one or two notable exceptions, bedrock exposures are buried beneath a much thicker interval of glacial drift and loess.

Actually, northwest Iowa is quite cosmopolitan in that it has terrain features which are developed in several of the other landform regions.

Figure 67. Within the Northwest Iowa Plains, long, gentle slopes and wide, shallow valleys with a distant, uncluttered skyline reflect the kinship of this area to the High Plains of the Dakotas.

Figure 68. Loess-mantled, gently rolling landscapes are characteristic of northwest Iowa. Clusters of trees are planted as windbreaks around farmsteads on this otherwise open plain.

It resembles the Iowan Surface in overall appearance. However, its dominant surface material is loess, reflecting the close proximity to the Western Loess Hills and to the Missouri and Big Sioux River source areas (fig. 22). The contact between the loess and the more clayey glacial till beneath results in the occasional occurrence of hydrologic phenomena observed earlier on the Southern Iowa Drift Plain—the development of springs and seeps where ground water moves along the contact with the relatively impermeable till layer and intersects a sloping land surface. And finally, the eastern half of this region is tied to the Wisconsinan glacial episode, illustrated so graphically in the landscapes of the Des Moines Lobe to the east. A sheet of drift, named the Tazewell Drift, (fig. 25), can be identified in this area based upon its stratigraphic position with respect to the more recent Cary Drift to the east, and based on radiocarbon dates which correlate with known Tazewell deposits in Illinois. Further differentiation is possible by examination of compositional and textural properties of the till. However, because of the general absence of moraines and the uniformity of surface dissection throughout the area, these refinements of the till are not reflected in the appearance of the region's landscapes.

Like the Iowan Surface of northeastern Iowa, this region once was referred to as having "Iowan Drift." However, the Pleistocene history of this region now is interpreted much the same as that of the Iowan Surface, with minor variations. The two drift sheets on which the northwest Iowa landscapes developed are Kansan and Tazewell (Wisconsinan). Paleosols on the older Kansan till were stripped away during a Wisconsinan-age erosion cycle that also affected the Tazewell Drift, resulting in similar drainage patterns across the entire region. A continuous mantle of loess drapes the region and obscures its boundary with the Western Loess Hills and the Southern Iowa Drift Plain.

Though bedrock exposures are rare in this part of Iowa, outcrops of Cretaceous-age rock formations occur along the Missouri Valley bluffs beneath the loess and glacial drift that usually cover them from view. Also, in the northwest corner of Lyon County, there are limited outcrops of the oldest exposed rock formation in Iowa—the Sioux Quartzite (fig. 12). The Sioux Quartzite has a distinctive pink to reddish color, and when looked at closely, one can see rounded grains of quartz sand that are tightly cemented by silica which gives the rock a glassy appearance. The term *quartzite* is applied to such a hard, durable quartz sandstone. Sediments that comprise the Sioux Quartzite were deposited in Precambrian time, at least 1.2 billion years ago. In Gitchie Manitou State Park, the colorful outcrops form low rounded mounds, often partially covered with pale green lichens (fig. 69). Many of the rock surfaces exhibit a high polish from years of exposure to the action of wind and weather.

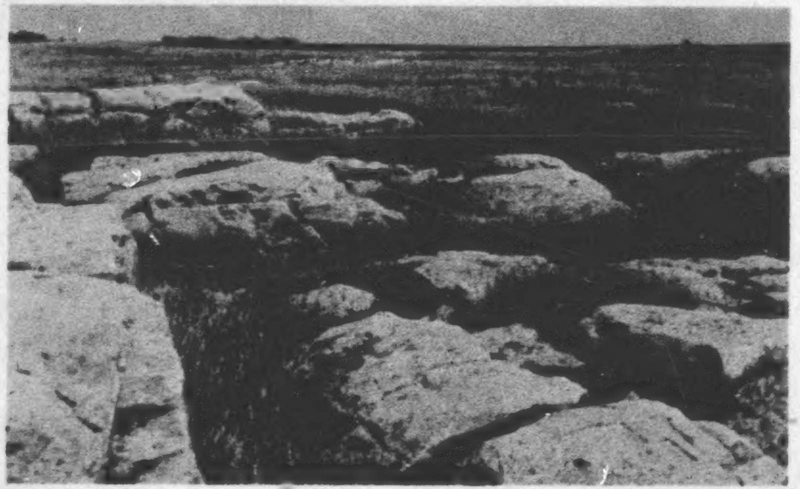


Figure 69. Ledges of pink Sioux Quartzite, Iowa's oldest exposed rock formation, are seen here near the Iowa-Minnesota border. Note the rounded, polished corners of the outcrop blocks, and the even skyline of the plain in the background. Photo by Donald L. Koch.

Figure 70. Extensive sand and gravel deposits, such as this one near the Missouri River valley, are found beneath the glacial till or as alluvial deposits within the region. Note the stratification of the various sand and gravel layers and the concentrations of similar-sized material, characteristic of water-deposited sediments.

As with most of the rest of Iowa, the terrain and soils of this region are well suited to the cultivation of crops, with some pastureland on the steeper slopes. However, with the low moisture available in this part of the state, water-conservation measures are particularly important. Sand and gravel resources from alluvial and drift deposits of the region are used for road construction and maintenance (fig. 70). The Sioux Quartzite also is used as a source of road aggregate in this part of Iowa, as well as in neighboring Minnesota and South Dakota.

EPILOGUE

When the Apollo astronauts landed on the moon, the world's attention focused on the strangeness of a desolate and cratered lunar landscape, and marveled at the courage and scientific achievement of this "...one giant leap for mankind." As these men took that symbolic first step into space, they also looked back at their home planet, with graphic descriptions and vivid photographs of Earth as a sphere of blue-green oceans, brownish land masses, and white polar ice caps veiled in swirled patterns of clouds. There probably has been no greater step forward in mankind's perception of his own environment than that taken on this historic mission to a new frontier. Our lands, waters and skies have new meanings for us now that they have been seen from this vantage point. For the life that is sustained by these physical environments, Joseph Wood Krutch thoughtfully observed at the close of his essay, *The Day of the Peepers*, "Don't forget, we are all in this together."

So we are—all in this together. These are days when we are increasingly aware of our natural environment's particular strengths and weaknesses, and that we and our activities are not separable from that environment. The land is certainly an integral part of the natural systems at work on our planet. It may record time by a different clock than human beings reckon by, but it is no less sensitive to day-by-day events. Man may modify the land for his purposes, but it is wise to remember that he must use it in accordance with the limits established by its geologic history and governed now by the shape of the land's surface, the materials beneath the surface and the relationship of the land to surface and subsurface sources of water.

We started this discussion by noting the importance of the land to Iowa's early pioneers. They had no choice but to consider the land carefully for what it could offer in terms of landmarks, shelter, nourishment and safety. With our more comfortable and leisurely means of travel, we are free to turn a more inquisitive eye to the landscape—to study its forms, learn of its history, enjoy its beauty and appreciate its importance to us and to our environment.

Appendix I

IOWA PARKS AND PRESERVES

The following list of parks and preserves in Iowa is indexed by landform region. Many of these public recreation areas are excellent showplaces of landscape features that characterize the region. Others are recreational oases of rock and woodland along river valleys that dissect the landform region. Between the years 1951 and 1960, Charles S. Gwynne, professor of geology at Iowa State University, wrote a series of popular articles on the geology of Iowa State Parks. These articles appeared in the Iowa Conservationist magazine, and also are indexed here, with publication date, to provide additional information on these public access areas.

PALEOZOIC PLATEAU

Bellevue: Jackson Co.; Scenic area of bedrock-controlled topography adjoining Mississippi Valley; December 1952.

Bixby: Clayton Co.; Karst features in limestone bedrock along Niagara Escarpment; June 1953.

Bluffton Fir Stand State Preserve: Winneshiek Co.; Scenic forested area of bedrock-controlled terrain.

Brush Creek Canyon State Preserve: Fayette Co.; Scenic bedrock-controlled topography along Niagara Escarpment; July 1953.

Cold Water Spring State Preserve: Winneshiek Co.; Scenic bedrock-controlled topography containing spring entrance to Cold Water Cave.

Decorah Ice Cave State Preserve: Winneshiek Co.; Karst features in bedrock-controlled terrain; limestone walls coated with ice.

Echo Valley: Fayette Co.; Bedrock-controlled topography along Niagara Escarpment; January 1955.

Effigy Mounds National Monument: Allamakee Co.; Scenic bedrock-controlled topography, and archaeological interest.

Fish Farm Mounds State Preserve: Allamakee Co.; Alluvial terrace at base of Mississippi Valley bluffs, bedrock-controlled terrain, and archaeological interest.

Fort Atkinson State Preserve: Winneshiek Co.; Area of geologic *type-section* of Ft. Atkinson Member, Maquoketa Shale, and historical interest; August 1954.

Julian Dubuque Monument Preserve: Dubuque Co.; Scenic overlook of Mississippi Valley from bedrock-controlled uplands.

McGregor Heights: Clayton Co.; Scenic overview of Mississippi River valley from bedrock-controlled uplands.

Merritt Forest State Preserve: Clayton Co.; Virgin forest stand in scenic bedrock-controlled topography.

Pikes Peak: Clayton Co.; Bedrock-controlled topography with scenic view of Mississippi alluvial plain; April 1951.

St. James Lutheran Church State Preserve: Winneshiek Co.; Scenic view of Ft. Atkinson and Turkey River valley; bedrock-controlled terrain.

Turkey River Mounds State Preserve: Clayton Co.; Scenic bedrock-controlled terrain, and Indian mounds.

White Pine Hollow State Preserve: Dubuque Co.; Rough, forested terrain along Niagara Escarpment.

Yellow River State Forest: Allamakee Co.; Scenic forested areas of bedrock-dominated terrain.

WESTERN LOESS HILLS

Preparation Canyon: Monona Co.; Characteristic scenic loess hills topography; June 1956.

Stone Park: Woodbury Co.; Scenic views along dissected loess bluffs overlooking Big Sioux River valley; December 1951.

Waubonsie: Fremont Co.; Scenic area of loess hills bordering Missouri River valley; August 1953.

ALLUVIAL PLAINS

DeSoto Bend National Wildlife Refuge: Harrison Co., Iowa—Washington Co., Nebraska; Oxbow lake from earlier Missouri River meander, and wildlife interest.

Fairport: Muscatine Co.; Alluvial plain of Mississippi River.

George Wyth Memorial: Black Hawk Co.; Alluvial plain of Cedar River valley; October 1958.

Heery Woods: Butler Co.; Alluvial plain of Shell Rock River; December 1958.

Lake Manawa: Pottawattamie Co.; Oxbow lake from earlier meander in Missouri River; September 1953.

Lewis and Clark: Monona Co. (Blue Lake); Oxbow lake from earlier meander of Missouri River; December 1953.

Walnut Woods: Polk Co.; Alluvial plain of Raccoon River; June 1954.

Wilson Island: Pottawattamie Co.; Alluvial plains and meander scars adjoining DeSoto Bend.

DES MOINES LOBE

Ambrose A. Call: Kossuth Co.; Glaciated terrain of Algona Moraine; May 1953.

Barkley Memorial Preserve: Boone Co.; Scenic forested area along Elkhorn Creek cut into Bemis Moraine upland.

Big Creek Lake: Polk Co.; Man-made lake near Saylorville Reservoir on Bemis Moraine.

Black Hawk Lake: Sac Co.; Glacial lake on Bemis Moraine; October 1952.

Cayler Prairie State Preserve: Dickinson Co.; Virgin prairie on Altamont Moraine.

Clear Lake: Cerro Gordo Co.; Glacial lake on Bemis Moraine; April 1958.

Dolliver Memorial: Webster Co.; Sandstone bedrock exposed along Des Moines River valley, with ground-moraine upland; March 1952.

Emerson Bay: Dickinson Co. (West Okoboji); Glacial lake on Altamont Moraine.

Fort Defiance: Emmet Co.; Tributary of the Des Moines River eroding into glaciated terrain of Altamont Moraine; October 1956.

Frank A. Gotch: Humboldt Co.; Forks of the Des Moines River cut into ground-moraine uplands.

Freda Hafner Kettlehole: Dickinson Co.; Prairie area on the Altamont Moraine including a depression formed by melting glacial ice.

Gull Point: Dickinson Co. (West Okoboji); West shore of glacial lake on Altamont Moraine; February 1952.

Holst State Forest: Boone Co.; Wooded area adjoining Des Moines River valley through Bemis Moraine.

Isthmus Access: Dickinson Co. (East Okoboji); Glacial lake on Altamont Moraine.

Kalsow Prairie State Preserve: Pocahontas Co.; Virgin prairie on ground moraine; January 1956.

Kearney: Palo Alto Co. (Five Island Lake); Glacial lake on Humboldt Moraine; July 1954.

Lake Cornelia: Wright Co.; Glacial lake on Altamont Moraine.

Ledges: Boone Co.; Scenic sandstone bedrock exposed along tributary to Des Moines River valley, with Bemis Moraine upland; October 1951.

Lennon Mill: Guthrie Co.; Raccoon River valley adjacent to Bemis Moraine.

Lost Island Lake: Palo Alto Co.; Glacial lake on Altamont Moraine; January 1954.

Lower Gar Access: Dickinson Co. (Lower Gar Lake); Glacial lake on Altamont Moraine.

Marble Beach: Dickinson Co. (Spirit Lake); Glacial lake on Altamont Moraine.

Margo Frankel Woods: Polk Co.; Wooded area on Bemis Moraine overlooking Des Moines River valley.

McIntosh Woods: Cerro Gordo Co. (Clear Lake); Wooded area adjoining glacial lake on Bemis Moraine; May 1955.

Mini-Wakan: Dickinson Co. (Spirit Lake); Glacial lake on Altamont Moraine; October 1957.

Okamanpedan: Emmet Co. (Tuttle Lake); Glacial lake on Algona Moraine.

Pikes Point: Dickinson Co. (West Okoboji); East shore of glacial lake on Altamont Moraine; January 1960.

Pillsbury Point: Dickinson Co. (West Okoboji); East shore of glacial lake on Altamont Moraine.

Pilot Knob State Preserve: Hancock Co.; Scenic, forested morainal knob on Altamont Moraine; January 1952.

Pilot Mound State Forest: Boone Co.; Wooded area on mound of Altamont Moraine.

Rice Lake: Winnebago Co.; Glacial lake on Altamont Moraine.

Silver Lake Fen State Preserve: Dickinson Co.; Marsh area on Bemis Moraine.

Springbrook: Guthrie Co.; Dissected edge of Bemis Moraine, adjoining Middle Raccoon River; April 1952.

Spring Lake: Greene Co.; Bemis Moraine near edge of Altamont Moraine.

Steamboat Rock: Hardin Co.; Valley of the Iowa River along east edge of Bemis Moraine.

Stinson Prairie State Preserve: Kossuth Co.; Virgin prairie near edge of Algona Moraine.

Trappers Bay: Dickinson Co. (Silver Lake); Glacial lake on Bemis Moraine.

Twin Lakes: Calhoun Co.; Glacial lakes on ground moraine; March 1953.

Union Slough National Wildlife Refuge: Kossuth Co.; Marsh area on Algona Moraine, and wildlife interest.

Woodman Hollow State Preserve: Webster Co.; Ravine cut into ground-moraine uplands adjoining Des Moines River valley; March 1959.

SOUTHERN IOWA DRIFT PLAIN

Bob White: Wayne Co.; Man-made lake on stream-dissected drift plain; December 1957.

Cold Springs: Cass Co.; East Nishnabotna River valley cut into drift plain uplands; April 1954.

Elk Rock: Marion Co. (Red Rock Reservoir); Man-made lake on stream-dissected drift plain.

Geode: Henry Co.; Man-made lake on stream-dissected drift plain; July 1951.

Green Valley: Union Co.; Man-made lake on stream-dissected drift plain.

Honey Creek: Appanoose Co. (Rathbun Reservoir); Man-made lake on stream-dissected drift plain.

Lacey-Keosauqua: Van Buren Co.; Scenic, Des Moines River valley cut into drift plain uplands with bedrock exposed; August 1951.

Lake Ahquabi: Warren Co.; Man-made lake on stream-dissected drift plain; July 1952.

Lake Anita: Cass Co.; Man-made lake on stream-dissected drift plain.

Lake Darling: Washington Co.; Man-made lake on stream-dissected drift plain.

Lake Keomah: Mahaska Co.; Man-made lake on stream-dissected drift plain; October 1953.

Lake Macbride: Johnson Co.; Man-made lake adjoining Coralville Reservoir on stream-dissected drift plain; July 1958.

Lake of Three Fires: Taylor Co.; Man-made lake on stream-dissected drift plain; February 1954.

Lake Wapello: Davis Co.; Man-made lake on stream-dissected drift plain; September 1954.

Malchow Indian Mounds State Preserve: Des Moines Co.; Scenic, dissected drift plain overlooking Mississippi Valley, and archaeological interest.

Maquoketa Caves: Jackson Co.; Scenic area of karst development in limestone underlying thin drift; June 1951.

Nine Eagles: Decatur Co.; Man-made lake on dissected drift plain; November 1957.

Oakland Mills: Henry Co.; Skunk River-dissected drift plain; March 1956.

Old State Quarry State Preserve: Johnson Co.; Dissected drift plain adjoining Coralville Reservoir where the State Quarry Limestone was quarried; *type-section* area and historical interest.

Palisades-Kepler: Linn Co.; Cedar River-dissected drift plain with bedrock palisades exposed; September 1951.

Pammel: Madison Co.; Scenic, Middle River-dissected drift plain with bedrock exposed; November 1951.

Pine Lake: Hardin Co.; Man-made lake on stream-dissected drift plain; May 1952.

Prairie Rose Lake: Shelby Co.; Man-made lake on stream-dissected drift plain.

Red Haw Lake: Lucas Co.; Man-made lake on stream-dissected drift plain; June 1958.

Rock Creek: Jasper Co.; Man-made lake on stream-dissected drift plain; May 1958.

Sharon Bluffs: Appanoose Co.; Bluffs area bordering Chariton River-dissected drift plain; January 1958.

Sheeder Prairie State Preserve: Guthrie Co.; Virgin prairie on stream-dissected drift plain.

Shimek State Forest: Lee-Van Buren Co.; Woodlands in vicinity of Des Moines River-dissected drift plain.

Silver Lake: Delaware Co.; Natural lake within stream-dissected drift plain.

M. A. Stainbrook State Preserve: Johnson Co.; Glacial grooves and fossiliferous limestone formations exposed along Coralville Reservoir.

Starrs Cave State Preserve: Des Moines Co.; Drift plain dissected by Flint Creek with scenic limestone exposures of the Starrs Cave Formation (*type-section*).

Stevens State Forest: Lucas-Monroe-Davis-Appanoose Co.; Stream-dissected drift plain.

Swan Lake: Carroll Co.; Man-made lake on stream-dissected drift plain.

Toolesboro National Historic Landmark: Louisa Co.; Upland drift plain adjoining confluence of Iowa and Mississippi River valleys.

Viking Lake: Montgomery Co.; Man-made lake on stream-dissected drift plain; September 1958.

Wapsipinicon: Jones Co.; Wapsipinicon River-dissected drift plain with bedrock exposed; August 1952.

Wildcat Den: Muscatine Co.; Scenic, stream-dissected drift plain adjacent to Mississippi Valley with bedrock exposed; June 1952.

Williams Prairie State Preserve: Johnson Co.; Native prairie on dissected drift plain.

Woodthrush Woods State Preserve: Jefferson Co.; Woodlands on dissected drift plain.

IOWAN SURFACE

Backbone: Delaware Co.; Scenic, Maquoketa River-dissected drift plain with bedrock exposed; May 1951.

Beaver Meadow: Butler Co.; Gently rolling drift plain; January 1959.

Beeds Lake: Franklin Co.; Man-made lake on stream-dissected drift plain adjacent to Des Moines Lobe; May 1957.

Clay Prairie State Preserve: Butler Co.; Virgin prairie on gently rolling drift plain.

Hayden Prairie State Preserve: Howard Co.; Virgin prairie on gently rolling drift plain.

Pioneer: Mitchell Co.; Little Cedar River valley in gently rolling drift plain.

Union Grove: Tama Co.; Man-made lake adjoins paha ridge on rolling drift plain; April 1953.

NORTHWEST IOWA PLAINS

Gitchie Manitou State Preserve: Lyon Co.; Oldest bedrock formation exposed in Iowa—Sioux Quartzite, bordering Big Sioux River valley; March 1951.

Mill Creek: O'Brien Co.; Man-made lake on dissected drift plain; April 1959.

Oak Grove: Sioux Co.; Scenic bluffs bordering Big Sioux River valley; November 1952.

Storm Lake: Buena Vista Co.; Natural lake on drift plain adjacent to Des Moines Lobe; February 1953.

Wanata: Clay Co.; Little Sioux River-dissected drift plain; September 1952.

Wittrock Indian Village State Preserve: O'Brien Co.; Stream-dissected drift plain with archaeological interest.

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GLOSSARY

Terms defined in this glossary are italicized in the text.

alluvium (alluvial): unconsolidated sediments of clay, silt, sand and gravel deposited by a stream or running water.

aquifer: a water-bearing formation.

basement: a complex of undifferentiated igneous and metamorphic rocks that form the crust of the Earth below the oldest sedimentary deposits of an area.

boulder-clay: descriptive synonym for glacial till.

carbon-14: a radioactive isotope of carbon, having a half-life of 5,660 years, and useful in dating organic materials and associated events during the last 40,000 years.

catsteps: a series of steps or terraces formed by natural slumping along steep slopes of thick loess deposits in western Iowa.

dendritic: in a branching pattern, reaching irregularly in all directions.

drift: unconsolidated material (clay, sand, gravel, boulders) transported and deposited by glacial ice or its meltwater.

end moraine: an arcuate or crescent-shaped ridge of glacial drift accumulated along the margins of stationary glacial ice.

erratics: rock fragments carried by glacial ice and deposited at some distance from their original outcrop.

escarpment: a steep, abrupt slope breaking the continuity of the land by separating two surface areas; also, such a slope or rock face marking the outcrop belt of a resistant bedrock layer.

evapotranspiration: water loss from the land to the atmosphere by transpiration of plants and evaporation from soil.

ferretto zone: reddish-brown clay paleosol developed on glacial till during Late Sangamon time.

floodplain: level land adjacent to a river channel, constructed by the river, and covered with water when river overflows its banks.

geomorphology: the description and study of the origin of the Earth's surface features or landforms.

glacial grooves: straight, parallel furrows carved into a bedrock surface by rock fragments lodged in the base of moving glacial ice.

ground moraine: nearly level areas underlain by ice-transported materials deposited during uniform melting phases of glacial ice.

gumbotil: a gray, clay paleosol developed on glacial till during interglacial weathering; sticky and plastic when wet.

Holocene: marks the epoch of geologic time from close of the Pleistocene to present, or approximately the last 10,000 years.

hydrologic cycle: the constant circulation of water from the sea, through the atmosphere, to the land and return to the sea for evaporation.

infrared photography: photographic recording of a scene on film sensitive to wavelengths just beyond the red end of the visible light spectrum; particularly used in aerial photography where resulting false-color images will show healthy vegetation in tones of red.

joint: a plane of weakness in a rock; a surface of actual or potential fracture or parting; often occurs parallel to, or at angles with other joints.

karst: topography developed from solution of underlying carbonate bedrock, and characterized by sinkholes, caves, and subterranean drainage.

knob and kettle topography: a rolling landscape of irregular, disconnected mounds and undrained depressions characteristic of recent glaciation and moraine accumulation.

landforms: distinctive physical features of the Earth's surface produced by natural causes.

loess: a porous, tan-colored, uniform-textured, wind-deposited sediment of silt-sized particles.

loess kindchen: irregular nodules or concretionary accumulations of calcium carbonate (lime) found in various sizes within loess deposits.

meanders: series of curves, bends, loops or windings along the course of a stream.

moraine: a ridge of glacial drift accumulated along the melting margins of glacial ice.

morphometric analysis: the measurement and mathematical analysis of landform shapes and dimensions.

order: the designation by numbered series (1, 2, 3, etc.) of the relative position of stream segments in a drainage-basin network; for example, the junction of two first-order streams produces a second-order stream.

outwash: sand and gravel carried away from a glacier margin by meltwater streams and deposited some distance downstream.

oxbow lake: a crescent- or horseshoe-shaped lake found in an abandoned meander on a river floodplain.

paha: a low, elongate ridge capped with loess on the Iowan Surface of northeast Iowa.

paleosol: a buried or fossil soil developed in past geologic time.

pebble band: a lag concentrate of stony debris found at the contact between the eroded glacial drift of the Iowan Surface and overlying sediments.

physiography: generally used as a synonym for geomorphology, though emphasis usually is placed on the more descriptive aspects of landform study.

pipestems: reddish-brown cylindrical concretions of iron, formed around plant roots in loess deposits.

Pleistocene: an epoch of geologic time synonomous with the "Great Ice Age," and containing the glacial and interglacial spans of time.

point bar: alluvial deposits accumulated on the inside curve of a migrating meander loop.

prairie pothole: a closed, undrained depression usually containing water or a marsh; wetlands associated with the pitted, poorly drained surface of recently glaciated terrain.

quartzite: a hard sandstone consisting of quartz grains and tightly cemented with silica.

Quaternary: consists of both the Pleistocene and Holocene epochs of geologic time, approximately the last 1.5 to 2 million years.

radioisotope dating: dating of rock, sediments, or fossil material by measurement of remaining radioactive isotopes of various elements.

relief: differences in elevation, unevenness or irregularity of the land surface.

remote sensing: examination of the Earth's surface from a distance, with camera and film combinations sensitive to different bands of the electromagnetic spectrum.

recessional moraine: an end moraine built during a temporary pause in the general wasting or recession of glacial ice from an area.

sinkholes: circular, closed depressions on the land surface resulting from collapse into solution cavities in the underlying limestone bedrock.

speleothem: a cave formation; any secondary mineral deposit that is formed in a cave by the action of water.

stone line: see *pebble band.*

striations: tiny, parallel furrows engraved into a rock surface or fragment by ice movement; smaller than *glacial grooves.*

stratigraphy: the layered arrangement of consolidated and unconsolidated rock strata, and their chronologic order of sequence.

tabular: having a flat surface.

terminal moraine: an end moraine that marks the maximum extent of a glacier.

terrace: a level plain at an elevated position within a stream valley, marking an earlier floodplain position.

till: unsorted, unstratified glacial drift; a heterogeneous mixture of clay, sand, gravel and boulders; *boulder-clay.*

topography (topographic): the general configuration of natural or physical features of the land surface.

type-section: geographic locality where a sequence of strata was originally described, and used thereafter as a comparative standard.

unconsolidated: loosely arranged, not cemented.

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